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FINAL WORK PLAN

PHASE I RFI/RI WORK PLAN
FOR OU 11

ROCKY FLATS PLANT

U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant
Golden, Colorado

ENVIRONMENTAL RESTORATION PROGRAM

DECEMBER 18, 1991

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EXECUTIVE SUMMARY

This document presents the Work Plan for the Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) of Operable Unit No. 11 (OU11) at the Rocky Flats Plant (RFP), Jefferson County, Colorado. Key portions of this Work Plan include the Site Characterization, Applicable or Relevant and Appropriate Requirements (ARARs), the Conceptual Model, Data Quality Objectives (DQOs), RFI/RI Tasks, the Field Sampling Plan (FSP), the Baseline Risk Assessment Plan (BRAP) and the Environmental Evaluation Plan (EEP). The FSP is the most vital portion of the Work Plan as it presents the investigative activities that will be implemented to evaluate the presence or absence of contamination within OU11. The FSP presented in this Work Plan is based on the requirements of the Interagency Agreement (IAG) among the U.S. Department of Energy, the U.S. Environmental Protection Agency, and the State of Colorado Department of Health.

As required by the IAG, this Phase I RFI/RI Work Plan addresses characterization of source areas at OU11. A subsequent Phase II RFI/RI will investigate the nature and extent of groundwater and air contamination and evaluate potential contaminant migration pathways. OU11 source areas include the former spray application areas and delivery pipelines from which potential releases could have occurred.

The initial step in the development of this Work Plan was to review available existing information on the West Spray Field. This information was used to characterize the site physical conditions and to develop a conceptual model of contaminant transport that identifies potential exposure pathways at OU11. Based on this characterization, DQOs were developed to describe the quality and quantity of data to be addressed within the RFI/RI. Through application of the DQO process, site-specific RFI/RI goals and data needs were established. These site-specific goals have been developed within the broad framework of characterizing OU11 source areas.

The following general goals for the OU11 RFI/RI were identified:

- Characterize the physical features;
- Characterize radionuclide, organic and inorganic contamination in surficial soil and the vadose zone;
- Collect data to support the Human Health Risk Assessment; and
- Collect data to support an Environmental Evaluation.

Within these broad objectives, site-specific data needs have been identified based on the conceptual model; on preliminary identification of contaminant-specific ARARs for OU11; and on data needs identified for the Baseline Risk Assessment. These data needs will be addressed during the field sampling phase of the RFI/RI which is discussed within the FSP section of this Work Plan. The FSP is briefly summarized below.

SOIL

A radiation survey and surficial soil sampling will be used to characterize potential contamination in surficial soil within the OU11 boundaries. The radiation survey will be conducted on a 150 foot grid spacing using a germanium detector, and the surficial soil sampling will be conducted on approximately 300-foot grid center points. The soil samples will be analyzed for Target Analyte List (TAL) metals, inorganics and nitrates.

SEDIMENT

Sediment samples will be collected from natural drainage channels within OU11 and from sediments collected in the vicinity of a historically breached berm at Walnut Creek. Analyses will be the same as for the soil samples.

VADOSE ZONE

Soil samples will be collected from test pits excavated approximately 1.5 meters into the vadose zone. Chemical analyses will be the same for the soil samples collected from the test pits with the addition of Target Compound List (TCL) volatiles. Also, the geotechnical analyses of grain size, density, moisture content, grading and plasticity will be performed on the soil samples. If chemical analyses indicate that elevated levels of contaminants are present in the test pit samples then boreholes will be drilled to characterize deeper soils within the vadose zone.

TERRESTRIAL BIOTA

Qualitative and quantitative field surveys will be conducted. Vegetation, wildlife/habitat types, and wetlands/riparian zones will be identified as part of the qualitative surveys. Vegetation (aboveground biomass), wetlands vegetation, and small mammals will be sampled as part of quantitative surveys and analyzed for radionuclides.

Data collected during the OU11 RFI/RI will be incorporated into the existing Rocky Flats Environmental Database System (RFEDS) database. These data will be used to better define site characteristics, source characteristics, and the nature and extent of contamination; and to support the Baseline Risk Assessment (Human Health and Environmental Evaluation). An RFI/RI Report will be prepared summarizing the data obtained during the field investigation program.

In addition, the data will be thoroughly evaluated within the Baseline Risk Assessment and the Environmental Evaluation.

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LIST OF ACRONYMS

AEC	Atomic Energy Commission
AIP	Agreements in Principle
ARAR	Applicable or Relevant and Appropriate Requirement
AWQC	Ambient Water Quality Criteria
BCF	bioconcentration factor
BNA	base neutral extractables
BRA	Baseline Risk Assessment
CAA	Clean Air Act
CAD	Corrective Action Decision
CCR	Colorado Code of Regulations
CDH	Colorado Department of Health
CDOW	Colorado Department of Wildlife
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program
CMS	Corrective Measures Study
COC	contaminants of concern
CRP	Community Relations Plan
CWA	Clean Water Act
CWQCC	Colorado Water Quality Control Commission
DMC	derived media concentrations
DOE	U.S. Department of Energy
DRCOG	Denver Regional Council of Governments
DQO	data quality objective
EE	Environmental Evaluation
EER	Environmental Evaluation Report
EEWP	Environmental Evaluation Work Plan
Eh	oxidation reduction potential
EIS	Environmental Impact Statement
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ER	Environmental Restoration
ERDA	Energy Research and Development Administration
F	Fahrenheit
FIDLER	Field Instrument for Detection of Low-Energy Radiation
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FS	feasibility study
FSP	Field Sampling Plan
GC	gas chromatograph
GPR	ground-penetrating radar
GRRASP	General Radiochemistry and Routine Analytical Services Protocol
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HSL	Hazardous Substance List
HSP	Health and Safety Plan
IAG	Interagency Agreement
IHSS	Individual Hazardous Substance Site

IM	Interim Measure
IPPCD	Interim Plan for Prevention of Contaminant Dispersion
IRA	Interim Remedial Action
IRIS	Integrated Risk Information System
ITPH	Interceptor Trench Pump House
ITS	Interceptor Trench System
MATC	maximum allowable tissue concentration
MDL	Minimum detection limit
MCL	maximum contaminant level
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
OPWL	Original Process Waste Lines
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PA	Protected Area
PARCC	precision, accuracy, representativeness, completeness, and comparability
PCB	polychlorinated biphenyl
PCN	Procedure Change Notice
PID	photoionization detector
PQL	Practical Quantitation Limit
PRP	potentially responsible parties
QAA	Quality Assurance Addendum
QA/QC	quality assurance/quality control
QAPjP	Quality Assurance Project Plan
RAAMP	Radiological Ambient Air Monitoring Program
RAGS-EEM	Risk Assessment Guidance for Superfund-Environmental Evaluation Manual
RAS	Routine Analytical Service
RCRA	Resource Conservation and Recovery Act
RfD	risk reference dose
RFEDS	Rocky Flats Environmental Database System
RFI	RCRA Facility Investigation
RFP	Rocky Flats Plant
RI	remedial investigation (CERCLA)
RME	reasonable maximum exposure
RO	Reverse Osmosis
ROD	Record of Decision
RSP	respirable suspended particulate
SAS	Special Analytical Services
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SEAM	Superfund Exposure Assessment Manual
SEP	Solar Evaporation Ponds
SOP	Standard Operating Procedure
SPHEM	Superfund Public Health Evaluation Manual
SSH&SP	Site Specific Health and Safety Plan
SWCS	Surface Water Control System
SWMU	Solid Waste Management Unit
TAL	Target Analyte List

TBC	To Be Considered
TCL	Target Compound List
TDS	total dissolved solids
THM	Total trihalomethanes
TIC	tentatively identified compound
TOC	total organic carbon
TSCA	Toxic Substances Control Act
USCS	United Soil Classification System
UV	ultraviolet
VOA	volatile organic analysis
VOC	volatile organic compound
WQCC	Water Quality Control Commission

1.0 INTRODUCTION

This document presents the Work Plan for the Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI)/Remedial Investigation (RI) for Operable Unit No. 11 (OU11) at the Rocky Flats Plant (RFP) in Jefferson County, Colorado.

This investigation is part of a comprehensive, phased program of characterization, remedial investigations, feasibility studies, and remedial/corrective actions currently in progress at RFP. These investigations are pursuant to an Interagency Agreement (IAG) among the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), and the Colorado Department of Health (CDH) dated January 22, 1991 (U.S. DOE, 1991a). The IAG addresses RCRA and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) issues. In accordance with the IAG, the CERCLA terms "remedial investigation" and "feasibility study" as used in this document are considered equivalent to the RCRA terms "RCRA Facility Investigation" and "Corrective Measures Study" (CMS), respectively. Also in accordance with the IAG, the term "Individual Hazardous Substance Site" (IHSS) is equivalent to the term "Solid Waste Management Unit" (SWMU).

As required by the IAG, this Phase I Work Plan addresses characterization of source areas within OU11. The Phase I RFI/RI will provide the source characterization information necessary to develop an Interim Measure/Interim Remedial Action (IM/IRA) Decision Document. The draft Proposed Phase I IM/IRA Decision Document shall provide the information required to recommend an alternative consistent with the State closure regulations. A subsequent Phase II RFI/RI will investigate the nature and extent of surface water, groundwater, and air contamination and evaluate potential contaminant migration pathways.

In this Work Plan, the existing information is summarized to characterize OU11, data gaps are identified, Data Quality Objectives (DQOs) are established, and a Field Sampling Plan (FSP) is presented to characterize site physical features and define contaminant sources.

The Phase I RFI/RI will be conducted in accordance with the Interim Final RCRA Facility Investigation (RFI) Guidance (U.S. EPA, 1989a) and Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (U.S. EPA, 1988a). Existing data and the data generated by the Phase I RFI/RI will be used to begin developing and screening remedial alternatives and to estimate the risks to human health and the environment posed by sources within OU11.

1.1 ENVIRONMENTAL RESTORATION PROGRAM

The DOE Environmental Restoration (ER) Program, designed for investigation and cleanup of environmentally contaminated sites at DOE facilities, is being implemented in five phases. Phase 1 (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns. Phase 2 (Remedial Investigations) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant pathways. Phase 3 (Feasibility Studies) includes evaluation of remedial alternatives and development of remedial action plans to mitigate environmental problems identified in Phase 2. Phase 4 (Remedial Design/Remedial Action) includes design and implementation of site-specific remedial actions selected on the basis of Phase 3 feasibility studies. Phase 5 (Compliance and Verification) includes monitoring and performance assessments of remedial actions as well as verification and documentation of the adequacy of remedial actions carried out under Phase 4. Phase 1 has been completed at the Rocky Flats Plant (DOE, 1986a), and this Work Plan is for activities under Phase 2 which is currently in progress for OU11.

1.2 WORK PLAN OVERVIEW

This Work Plan presents an evaluation and summary of previous data and investigation, defines data quality objectives and data needs based on that evaluation, specifies Phase I RFI/RI tasks, and presents the FSP for the Phase I RFI/RI.

Section 2.0 (Site Characterization) presents a comprehensive review and detailed analysis of available historical information, previous site investigations, recently published reports, available data, and site geology and hydrology as well as the known nature and extent of contamination in soils, groundwater, and surface water. Additionally, Section 2.0 presents a conceptual model for contaminant migration and exposure pathways based on site physical characteristics and available information regarding the nature and extent of contamination. Section 3.0 presents potential site-wide Applicable or Relevant and Appropriate Requirements (ARARs), as required by the IAG, and a discussion of their application to the RFI/RI activities at OU11. Section 4.0 discusses the DQOs and Work Plan rationale for the Phase I RFI/RI. Section 5.0 specifies tasks to be performed for the Phase I RFI/RI. The schedule for performance of Phase I RFI/RI activities is presented in Section 6.0. Section 7.0 presents the FSP to meet the objectives presented in Section 4.0. The Baseline Human Health Risk Assessment Plan is discussed in Section 8.0, and the Environmental Evaluation Work Plan (EEWP) is discussed in Section 9.0. Finally, the references used are presented in Section 2.0. The Quality Assurance Addendum is included as Section 10.0 and Section 11.0 contains the Field Sampling Plan.

1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION

The following subsections provide general information on the RFP and the surrounding region, including RFP history, regional land use and population data, and site conditions. Site-specific conditions at OU11 are addressed in Section 2.0.

1.3.1 Facility Background and Plant Operations

The RFP is a government-owned, contractor-operated facility which is part of the nationwide Nuclear Weapons Complex. The plant was operated for the U.S. Atomic Energy Commission (AEC) from its inception in 1951 until the AEC was dissolved in January 1975. At that time, responsibility for the plant was assigned to the Energy Research and Development Administration (ERDA), which was succeeded by the DOE in 1977. Dow Chemical U.S.A., an operating unit of DOW Chemical Company, was the prime operating contractor of the facility from 1951 until June 30, 1975. Rockwell International was the prime contractor responsible for operating the Rocky Flats Plant from July 1, 1975 until December 31, 1989. EG&G became the prime contractor at the RFP on January 1, 1990.

Operations at the RFP consist of fabrication of nuclear weapons components from plutonium, uranium, and nonradioactive metals (principally beryllium and stainless steel). Parts made at the plant are shipped elsewhere for assembly. In addition, the plant reprocesses components after they are removed from obsolete weapons for recovery of plutonium. Other activities at the RFP include research and development in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry and physics. Both radioactive and nonradioactive wastes are generated in the production processes. Current waste handling practices involve on-site and off-site recycling of hazardous materials, on-site storage of hazardous and radioactive mixed wastes, and off-site disposal of solid radioactive materials at another DOE facility.

However, the RFP operating procedures historically included both on-site storage and disposal of hazardous, radioactive, and radioactive mixed wastes. Preliminary assessments under the Environmental Restoration Program identified some of the past on-site storage and disposal locations as potential sources of environmental contamination.

1.3.2 Previous Investigations

Various site-wide studies have been conducted at the RFP to characterize environmental media and to assess the extent of radiological and chemical contaminant releases to the environment. The investigations performed prior to 1986 were summarized by Rockwell International (1986b and c) and include the following:

1. Detailed description of the regional geology (Malde, 1955; Spencer, 1961; Scott, 1960, 1963, 1970, 1972, and 1975; Van Horn, 1972 and 1976; Dames and Moore, 1981; and Robson et al., 1981a and 1981b);
2. Several drilling programs beginning in 1960 that resulted in construction of approximately 60 monitoring wells by 1982;
3. An investigation of surface water and groundwater flow systems by the U.S. Geological Survey (Hurr, 1976);
4. Environmental, ecological, and public health studies that culminated in an Environmental Impact Statement (U.S. DOE, 1980);
5. A summary report on groundwater hydrology using data from 1960 to 1985 (Hydro-Search, Inc., 1985);
6. A preliminary electromagnetic survey of the plant perimeter (Hydro-Search, Inc, 1986);
7. A soil-gas survey of the plant perimeter and buffer zone (Tracer Research, Inc., 1986); and

8. Routine environmental monitoring programs addressing air, surface water, groundwater, and soils (Rockwell International, 1975a through 1986a);

In 1986, two major investigations were completed at the plant. The first was the DOE Comprehensive Environmental Assessment and Response Program (CEARP) Phase 1 Installation Assessment (U.S. DOE, 1986a). This assessment included analyses and identification of current operational activities, active and inactive waste sites, current and past waste management practices, and potential environmental pathways through which contaminants could be transported. CEARP was later succeeded by the ER Program. A number of sites that could potentially have adverse impacts on the environment were identified. These sites were designated as SWMUs by Rockwell International (1987a). In accordance with the IAG, SWMUs are now designated as IHSSs, which were divided into three categories:

1. Hazardous substance sites that will continue to operate and need a RCRA operating permit;

2. Hazardous substance sites that will be closed under RCRA interim status; and

3. Inactive substance sites that will be investigated and cleaned up under Section 3004(u) of RCRA or CERCLA.

The second major investigation completed at the plant in 1986 involved a hydrogeologic and hydrochemical characterization of the entire plant site. Plans for this study were presented by Rockwell International (1986c) and study results were reported by Rockwell International (1986e). Investigation results identified areas considered to be significant contributors to environmental contamination.

1.3.3 Physical Setting

The RFP is situated on 6,550 acres (ac) (2,650 hectares [ha]), of federal property in Jefferson County, Colorado, 16 miles (mi) northwest of downtown Denver. The 385 ac (156 ha) main production facility of the RFP, within the plant's controlled area is surrounded by a 6,150 ac (2,491 ha) buffer zone which delineates the RFP boundary (Figure 1-1).

1.3.3.1 Location

The RFP is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1). Other surrounding cities include Boulder, Westminster, and Arvada, all of which are located less than 10 miles to the northwest, east, and southeast, respectively. The plant consists of approximately 6,550 acres of federal land in Sections 1 through 4 and 9 through 15 of T2S, R70W, 6th Principal Meridian. In general, plant buildings are located within a protected central area site of approximately 400 acres, and surrounded by a buffer zone of approximately 6,150 acres.

The RFP is bounded on the north by State Highway 128, on the east by Jefferson County Highway 17, (also known as Indiana Street), on the south by agricultural and industrial properties and Highway 72, and on the west by State Highway 93.

1.3.3.2 Topography

The RFP is located along the eastern edge of the southern Rocky Mountain Region immediately east of the Colorado Front Range. The plant site is located on a broad, eastward-sloping pediment that is capped by alluvial deposits of Quaternary age (Rocky Flats Alluvium). The pediment surface has a fan-like form, with its apex and distal margins approximately 2 miles east of the RFP. The tops of alluvial-covered pediments are nearly flat but slope gently eastward at 50 to 100 feet per mile (EG&G, 1991a). At the RFP, the pediment surface is dissected by a series of east-northeast trending stream-cut valleys. The valleys containing Rock Creek, North and South Walnut Creeks, and Woman Creek lie 200 to 250 feet below the level of the older pediment surface. These valleys are incised into the bedrock underlying alluvial deposits, but most bedrock is concealed beneath colluvial material accumulated along the gentle valley slopes. The combined effects of stream-cut topographic relief and the shallow dip of the bedrock units beneath the RFP suggest a potentially shallow depth to the Laramie formation in the valley bottoms.

1.3.3.3 Meteorology

The area surrounding the RFP has a semiarid climate which is characteristic of much of the central Rocky Mountain Region. Based on precipitation averages recorded between 1953 and 1976, the mean annual precipitation at the plant is 15 inches. Approximately 40 percent of the precipitation falls during the spring season, much of it as wet snow. Thunderstorms (June to August) account for an additional 30 percent of the annual precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, falling from October through May (U.S. DOE, 1980).

Winds at the RFP, although variable, are predominantly from the west-northwest. Stronger winds occur during the winter, and due to its location near the Front Range the area occasionally experiences Chinook winds with gusts up to 100 miles per hour. The canyons along the Front Range tend to channel the air flow during both up-slope and downslope conditions, especially when there is strong atmospheric stability (U.S. DOE, 1980).

Rocky Flats meteorology is strongly influenced by the diurnal cycle of mountain and valley breezes. Two dominant flow patterns exist, one during daytime conditions and one at night. During daytime hours, as the earth heats, air tends to flow toward the higher elevations (up-slope). During up-slope conditions, air flow generally moves up the South Platte River Valley and then enters the canyons into the Front Range. After sunset, the air against the mountain side is cooled and begins to flow toward the lower elevations (downslope). During downslope conditions, air flows down the canyons of the Front Range onto the plains (e.g., Hodgin, 1983 and 1984; and U.S. DOE, 1986a).

Temperatures at the RFP are moderate. Extremely warm or cold weather is usually of short duration. On average, daily summer temperatures range from 55 to 85 degrees Fahrenheit (°F), and winter temperatures range from 20 to 45°F. Temperature extremes recorded at the plant range from 102°F on July 12, 1971, to -26°F on January 12, 1963. The 24-year daily average maximum temperature for the period 1952 to 1976 is 76°F, the daily minimum is 22°F, and the average mean is 50°F. Average relative humidity is 46 percent (U.S. DOE, 1980).

1.3.3.4 Surface Water Hydrology

Three intermittent streams that flow generally from west to east drain the RFP area. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-2).

Rock Creek drains the northwestern corner of the buffer zone and flows northeastward through the buffer zone to its off-site confluence with Coal Creek. North and South Walnut Creeks and an unnamed tributary drain the northern portion of the plant complex. These three forks of Walnut Creek join in the buffer zone and flow to Great Western Reservoir approximately 1 mile east of the confluence. Flow is diverted around Great Western Reservoir into Big Dry Creek via the Broomfield Diversion Ditch. Rock Creek, North and South Walnut Creeks, and the unnamed tributary are intermittent streams. Flow occurs in these streams only after precipitation events and spring snowmelt. An east-west trending interfluve separates Walnut Creek from Woman Creek. Woman Creek drains the southern Rocky Flats buffer zone and flows eastward into Mower Reservoir. The South Interceptor Ditch is located between the plant and Woman Creek. The South Interceptor Ditch collects runoff from the southern portion of the plant complex and diverts it to pond C-2, where it is monitored in accordance with the RFP National Pollutant Discharge Elimination System (NPDES) permit (Rockwell 1985b).

The Church and McKay ditches cross the northern portion of the plant and run through the West Spray Field. In addition to these, there are four more ditches in the general vicinity of the Plant. The South Boulder Diversion Canal runs along the western up-gradient edge of the Plant.

1.3.3.5 Ecology

The ecology of the RFP is dominated by mixed grass prairie that includes mosaics of short and tall grass prairie, and short-grass steppe ecosystems. Grasses typical of the area include Canada bluegrass (*Poa compressa*), blue grama (*Bouteloua gracilis*), big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), green needlegrass (*Stipa viridula*), and mountain muhly (*Muhlenbergia montana*). The fork tip three-awn (*Aristida basiramea*), a grass listed as endangered in Colorado, is known to occur in the upper reaches of the Woman Creek drainage. Much of the RFP grasslands have apparently recovered from previous grazing pressure as evidenced by the prevalence of big bluestem and side-oats grama (*Bouteloua curtipendula*), two disturbance sensitive species. Yucca, cacti, and various sage (*Artemisia sp.*) are conspicuous in more xeric areas. Small wetland areas on valley floors and around seeps support stands of mature cottonwoods (*Populus sp.*) and various sedges, rushes and cattails. Shrubby areas on the upper ravine slopes include wild plum (*Prunus americana*), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus erythropoda*), and snowberry (*Symphoricarpos sp.*).

The fauna inhabiting the RFP and its buffer zone consists of species associated with western prairie regions. The most common large mammal is the mule deer (*Odocoileus hemionus*), with an estimated 100 to 125 permanent residents. There are a number of small carnivores, such as the coyote (*Canis latrans*), red fox (*Vulpes fulva*), striped skunk (*Mephitis*), and long-tailed weasel (*Mustela frenata*) in the area. Small herbivores can be found throughout the plant complex and buffer zone, including species such as the deer nigasi (*Peromyscus mannulatus*) white-tailed jackrabbit (*Lepus townsendii*), and the meadow vole (*Microtus pennsylvanicus*) (U.S. DOE, 1980).

Commonly observed birds include western meadowlarks (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), mourning doves (*Zenaidura macroura*), vesper sparrows (*Pooecetes gramineus*), western kingbirds (*Tyrannus vociferans*), black-billed magpies (*Pica*), American robins (*Turdus migratorius*), and yellow warblers (*Dendroica magnolia*). A variety of ducks, killdeer (*Charadrius vociferus*), and red-winged black birds (*Agelaius phoeniceus*) are seen in areas adjacent to ponds. Mallards (*Anas platyrhynochos*) and other ducks (*Anas sp.*) frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), ferruginous hawks (*Buteo regalis*), rough-legged hawks (*Buteo lagopus*), and great horned owls (*Bubo virginianus*) (U.S. DOE, 1980).

Bull snakes (*Pituophis melanoleucus*) and rattlesnakes (*Crotalus sp.*) are the most frequently observed reptiles. Eastern yellow-bellied racers (*Coluber constrictor flaviventris*) have also been seen. The eastern short-horned lizard (*Phrynosoma douglassi brevirostre*) has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle (*Chrysemys picta*) and the western plains garter snake (*Thamnophis radix*) are found in and around many of the ponds (U.S. DOE, 1980).

The streams and ponds support diverse aquatic communities. Bass (Micropterus salmoides), green sunfish (*Lepomis cyanella*), white suckers (*Catostomus commersoni*), and creek chubs (*Semotilus atromaculatus*) are common in streams and ponds. The tiger salamander (*Ambystoma tigrinum*) is common in ponds and wetland areas. Crayfish, snails, and many aquatic insects are also common and form an important prey base for aquatic food webs.

1.3.3.6 Surrounding Land Use and Population Density

The population, economics, and land use of areas surrounding the RFP are described in a 1989 Rocky Flats vicinity demographics report prepared by DOE (U.S. DOE, 1991b). This report divides general use of areas within 0 to 10 miles of the RFP into residential, commercial, industrial, parks and open spaces, agricultural and vacant, and institutional classifications, and also considers current and future land use near the RFP.

The majority of residential use within five miles of the RFP is located immediately northeast, east, and southeast of the plant. The 1989 population distribution within areas up to five miles of the RFP is illustrated in Figure 1-3. Commercial development is concentrated near residential developments north and southwest of Standley Lake as well as around the Jefferson County Airport, located approximately three miles northeast of the RFP. Industrial land use within five miles of the plant is limited to quarrying and mining operations. Open space lands are located northeast of the RFP near the City of Broomfield and in small parcels adjoining major drainages and small neighborhood parks in the cities of Westminster and Arvada. Standley Lake is surrounded by Standley Lake Park. Irrigated and non-irrigated croplands, producing primarily wheat and barley, are located northeast of the RFP near the cities of Broomfield, Lafayette, and Louisville; north of the RFP near Louisville and Boulder; and in scattered parcels adjacent to the eastern boundary of the plant. Several horse operations and small hay fields are located south of the RFP. The demographic report characterizes much of the vacant land adjacent to the RFP as rangeland (U.S. DOE, 1991b).

Future land use in the vicinity of the RFP most likely involves continued urban expansion, increasing the density of residential, commercial, and perhaps industrial land use in the areas. The expected trend in population growth in the vicinity of the RFP is also addressed in the DOE demographic study (U.S. DOE, 1991b). The report considers expected variations in population density by comparing the current (1989) setting to population projections for the years 2000 and 2010. A 21-year profile of projected population growth in the vicinity of the RFP can thus be examined. DOE's projections are based primarily on long-term population projections developed by the Denver Regional Council of Governments (DRCOG). Expected population density and distribution around the RFP for the years 2000 and 2010 are shown in Figures 1-4 and 1-5, respectively.

1.3.3.7 Regional Geology

This section briefly describes the geologic formations present in the general area of the RFP, but is limited to those formations of Upper Cretaceous Age or younger. This time span encompasses a stratigraphic thickness of over 9,000 feet, which is more than adequate to meet the goals of this Work Plan. The information provided herein is intended to provide a general geologic history of the area to aid in planning the FSP. This section summarizes previous relevant geologic investigations conducted at or near the RFP, including:

- Post-Closure Care Permit and Closure Plan, Rockwell, 1988a;
- Annual RCRA Ground-Water Monitoring Report for Regulated Units at Rocky Flats Units at Rocky Flats Plant, EG&G, 1990a;
- Geologic Characterization, EG&G, 1991c;

- A Guide to Uppermost Cretaceous Stratigraphy, Central Front Range, Colorado: Deltaic Sedimentation, Growth, Faulting, and Early Laramide Crustal Movement, Weimer, 1973;

- Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado, U.S.Geological Survey, Theodore Hurr, 1976; and

- EG&G on-going studies.

The RFP is located approximately four miles east of the Front Range section of the Southern Rocky Mountain provence on the western edge of the Colorado Piedmont section of the Great Plains Physiographic Provence (Spencer, 1961). It is located on a pediment alluvium which is underlain by approximately 10,000 feet of Pennsylvania to Upper Cretaceous sedimentary rocks that have been folded and faulted (Figure 1-6).

Depositional environments east of the Front Range in the Late Cretaceous period were influenced by the Laramide Orogeny which resulted in the uplift of the Colorado Front Range Mountains. The uplift caused a regression of the Cretaceous Sea from the west to the east, resulting in a lateral progradation of Pierre prodelta shales and siltstones, the Fox Hills delta front sandstones, the Laramie delta plain sandstones, claystones, and coals, and Arapahoe fluvial conglomerates, sandstones and claystones (Figure 1-7) (Weimer, 1973).

These formations are relatively distinct, from a regional perspective, and reflect increasingly higher gradients of deposition with correspondingly higher energy facies (EG&G, 1991a). However, lateral and vertical variations in the depositional history of the Arapahoe Formation have been observed as a function of localized tectonic surges (EG&G, 1991a). These surges created an accumulation of higher-energy, braided stream facies south of the RFP in the Golden area, in contrast to the lower-energy, meandering stream facies which occur in the RFP area (EG&G, 1991a). Interpretations of the sequence of deposition for the Laramie and Arapahoe

Formations include a system with a single continuous meandering channel and a system with multiple channels (EG&G, 1991).

Along the foothills west of the RFP, sedimentary strata are steeply east-dipping to overturned. West of the buffer zone, Upper Cretaceous sandstones of the Laramie formation make up an east-dipping (45° to 55°) hogback that strikes approximately north-northwest (Scott, 1960). These steeply dipping sedimentary strata flatten to less than two degrees under and east of the RFP (EG&G, 1991a). Sedimentary bedrock is unconformably overlain by Quaternary alluvium that caps the multi-aged pediment surfaces (Scott, 1965).

The geologic characteristics of the Upper Cretaceous Formations are described briefly below. These descriptions are ordered by geologic age beginning with the oldest.

- Pierre Shale Formation. The Pierre is a medium to dark gray, montmorillonite shale with minor thin laminae of limonitic siltstone and silty, very fine grained sandstone. Beneath the RFP, the Pierre is reported to be over 8,000 feet thick (EG&G, 1991a).

- Fox Hills Formation. The Fox Hills averages 75 feet thick and consists of thick-bedded to massive, very fine to medium-grained feldspathic sandstone which is grayish-orange to light gray in color. The sandstones are interlayered with thin beds of siltstone and claystone (EG&G, 1991a).

- Laramie Formation. The Laramie is approximately 800 feet thick and consists of an upper claystone unit and a lower sandstone and coal unit (Hurr, 1976). At the RFP, the lower unit is reported to be approximately 113 to 285 feet thick (EG&G, 1991a). Geologic logs indicate that it consists of thick (up to 50 feet) sandstones and coal beds ranging from two to eight feet thick. The sandstones are very fine to medium-grained. These sandstones can be subdivided into two major layers: the A Sand and the B Sand. The A Sand is the lowermost sand, located 5 to 40 feet above the top of the Fox Hills Sandstone, and is highly resistant to weathering. It is seen in the hogback ridges west of the site. The B Sand ranges from thin sandstones interbedded with organic-rich claystones to a massive sandstone (Hurr, 1976).

The upper unit is reported to be approximately 450 to 630 feet thick (Hurr, 1976). A resistivity survey of the RFP identified what is believed to be the contact between the upper and lower units at a depth of approximately 527 feet beneath the RFP (EG&G, 1991a). Geologic logs show that the upper unit consists of silty claystones and siltstones, and some fine-grained lenticular fluvial sandstones (EG&G, 1991a). Locally, sand layers are frequent enough at the interval 100 to 200 feet above the B Sand to be collectively termed the C Sand layer (Hurr, 1976). The silty claystones are light olive gray to olive black, massive, occasionally sandy, and contain carbonaceous material. Siltstones are also carbonaceous, with iron oxide nodules and slickensides along fractures (EG&G, 1991a).

- Arapahoe Formation. The Arapahoe Formation is the uppermost bedrock unit underlying most of the RFP. However, in the western portion of the site, it appears to have been completely eroded, leaving the upper claystone unit of the Laramie Formation as the upper bedrock unit. The Arapahoe consists primarily of claystones and silty claystones, and is approximately 150 feet thick in the center of the RFP (EG&G, 1991a). At least five mappable sandstones have been identified within the formation. The Arapahoe Sandstone No. 1 outcrops occasionally and subcrops extensively in the RFP area. Its thickness varies between 0 and 27 feet, and its aerial extent has been mapped according to the two depositional interpretations discussed above (EG&G, 1991a).

  Geologic logs indicate that Arapahoe sandstones are fine-to medium-grained, with some occasional conglomeratic lenses. Weathered sandstones are pale orange, yellowish-gray, and dark yellowish-orange, and unweathered sandstones are light gray to olive-gray. The sandstones are typically interlayered with clay lenses and are lenticular in geometry. The dominant claystones and silty claystones are light to medium olive-gray and appear dark yellowish orange where weathered. Iron-oxide staining is common in the upper 30 to 40 feet of the sandstones (EG&G, 1991a).

The gradational and transitional nature of the Laramie and overlying Arapahoe Formations makes the exact definition of the contact between them difficult. Regional surface mapping of the RFP in 1991 established field criteria which included frosted, well-rounded, coarser quartz grains, combined with the introduction of new lithologies signifying new source environments for the Arapahoe Formation. However, frosted quartz grains and coarser grained sandstones have been encountered in lower Arapahoe Formation units, which were mapped as Laramie Formation by the mapping effort. Investigations are continuing to resolve this prevailing uncertainty (verbal communication, Connie Dodge, EG&G, 1991b).

Quaternary deposits in the RFP area have been categorized into three types of pediment cover (Rocky Flats, Verdos, and Slocum Alluviums) and two types of valley fill (Louviers and Broadway). Additionally, recent alluvial valley fill deposits include the Piney Creek and Post Piney Creek Alluviums. These alluvial units have been correlated along the Front Range by their height above modern stream drainages (EG&G, 1991a) and are described briefly below:

- Rocky Flats Alluvium. The Rocky Flats is the oldest alluvial deposit in the RFP area and consists of poorly sorted, angular to rounded, coarse gravels, sands, and gravelly clay. Caliche amounts vary from trace to abundant. The alluvium occurs about 250 to 380 feet above modern stream drainages (EG&G, 1991a). It is a series of laterally coalescing alluvial fans deposited by streams on an erosional surface cut into the bedrock units (Hurr, 1976). Thickness at the type locality just south of the RFP is 50 feet, and ranges between 10 and 90 feet (Machette, 1973). Dominant lithologies include Precambrian quartzite, schist, and gneiss deposited by Coal Creek. Caliche ($CaCO_3$) mineralization in the interstices of alluvium ranges from a trace to almost 100 percent, and increases in thickness as the thickness of the alluvium decreases. This is due to the increased evapotranspiration from the water table, which leaves caliche as a residual deposit in the pore spaces (EG&G, 1991a).

- Verdos Alluvium. The Verdos consists of a sandy, cobbly to bouldery gravel deposited by Ralston Creek (Machette, 1973). The thickness of the Verdos ranges from 15 to 35 feet, and it occurs at 200 to 250 feet above modern streams. The Slocum Alluvium is composed of well-stratified, clayey, coarse gravel and coarse sand and its thickness ranges between 10 and 90 feet. It occurs at 80 to 120 feet above modern streams (EG&G, 1991a).

- Louviers and the Broadway Alluviums. These alluviums are composed of coarse sand and cobbly gravel and range between 10 and 25 feet in thickness. The Louviers forms well-developed terraces 40 to 80 feet above modern streams. The Broadway forms terraces between 25 and 45 feet above modern streams and occurs in channels cut into the Louviers (EG&G, 1991a).

- Pre-Piney Creek, the Piney Creek, and Post Piney Creek Alluviums. These alluviums represent the most recent deposits. The Pre-Piney Creek consists of silt and sand with pebbles lenses, the Piney Creek consists of clay, silt, sand, with some pebble beds, and the Post-Piney Creek consists of poorly consolidated, humic, fine-to medium-grained sandstone interbedded with a magnetite-rich sandstone (EG&G, 1991a).

1.3.3.8 Regional Hydrogeology

This section provides a brief description of the hydrogeologic system beneath the general area of the RFP. Pursuant to the goals of the Scope of Work for this Work Plan, it focuses on those water-bearing zones which are included within the stratigraphic units described in Section 1.3.3.7. These discussions are limited to the water-bearing zones found in the upper 200 feet of geologic material since below this depth the presence of claystones and siltstones would likely preclude vertical adversion and/or dispersion of contaminants to lower stratigraphic units.

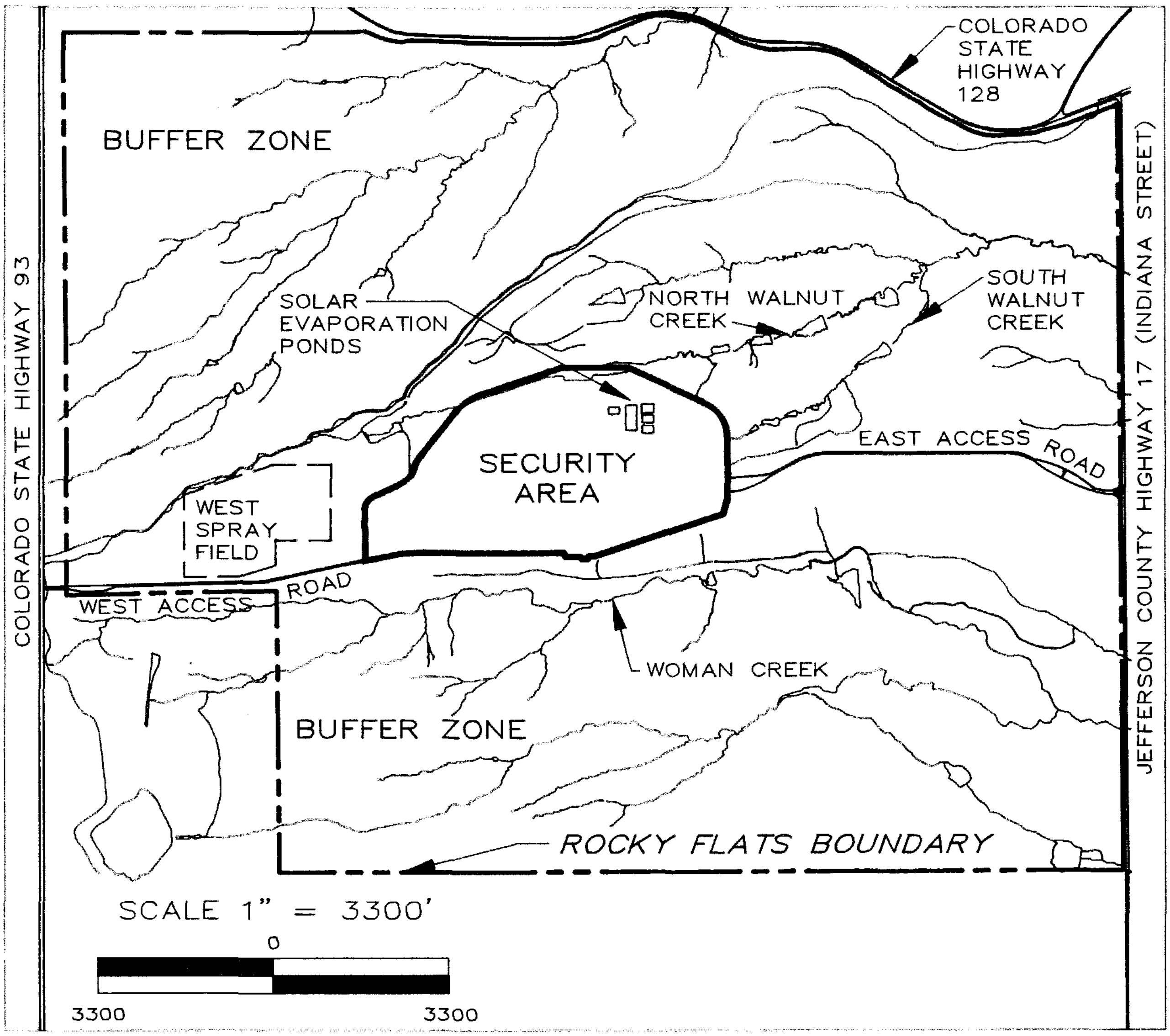
At the RFP there appears to be three hydrostratigraphic units in the Upper Cretaceous and Quaternary materials: the Rocky Flats Alluvial Hydrostratigraphic Unit, Arapahoe Hydrostratigraphic Unit, and Laramie-Fox Hills Hydrostratigraphic Unit. The hydrogeologic characteristics of each are briefly described below.

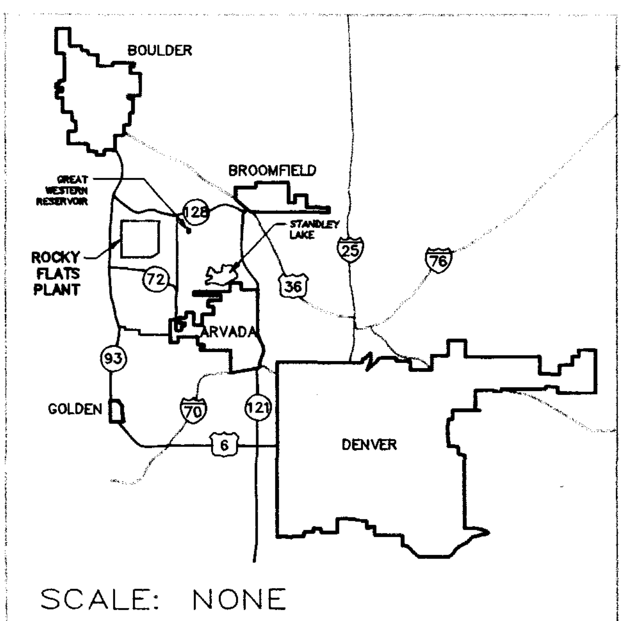
- Rocky Flats Hydrostratigraphic Unit. This water-bearing zone represents the shallow, unconfined water table aquifer at the RFP. It is present in both the Rocky Flats and Valley Fill Alluviums. The depth to water in this water-bearing zone is greatest in the western portion of the RFP (50 to 70 feet below ground surface), where the alluvium is thickest (EG&G, 1991a). Generally, this depth to water decreases as the thickness of the alluvium decreases to the east. Recharge to this water-bearing zone comes from direct infiltration of precipitation and from leakage from streams, ponds, and other surface water bodies (Hurr, 1976). Discharge is mainly to evapotranspiration, vertical seepage to the underlying bedrock aquifer, and seepage along slopes at the contact between the alluvium and the underlying bedrock (Hurr, 1976). Direction of groundwater flow generally follows topography to the east, and into stream drainages (where present). Hydraulic conductivity in the alluvial materials is reported to range from 5.3×10^{-4} to 2.1×10^{-5} cm/s (EG&G, 1990b and c).

- Arapahoe Hydrostratigraphic Unit. This water-bearing zone is the first bedrock aquifer encountered below the alluvium under the majority of the RFP. It is present in the sandstones of the Arapahoe and is confined by the overlying Arapahoe claystones. The exception to this is where the Arapahoe sandstones subcrop beneath the alluvial materials, which occurs with some frequency. At these locations the water-bearing zone is believed to be hydraulically connected to the overlying Rocky Flats Hydrostratigraphic Unit. Recharge to this hydrostratigraphic unit comes from leakage from the overlying alluvial hydrostratigraphic unit in those locations where the Arapahoe sandstone is unconfined (Hurr, 1976). Discharge occurs locally where the sandstone outcrops in stream drainages (Hurr, 1976). The hydraulic conductivity of this hydrostratigraphic unit is reported to be 10^{-6} cm/s, and this hydrostratigraphic unit is not believed to be capable of producing economical amounts of water (EG&G, 1991a).

- Laramie-Fox Hills Hydrostratigraphic Unit. This deep, confined water-bearing zone underlies the entire RFP, but is believed to be separated from the overlying Arapahoe Formation by several hundred feet of relatively impermeable claystones in the Upper Unit of the Laramie Formation (Hurr, 1976). However, near the western portion of the site, where the Arapahoe Formation and portions of the Laramie Formation are eroded, this aquifer may be closer to the surface (EG&G, continuing studies). Recharge to the Laramie-Fox Hills appears to be through infiltration of precipitation along the outcrops of the Laramie and Fox Hills Formations at the western boundary of the RFP (Hurr, 1976). It is unlikely that measurable amounts of recharge to this hydrostratigraphic unit could penetrate the upper claystone unit of the Laramie. Direction of flow in this hydrostratigraphic unit is reported to be to the east or southeast (Hurr, 1976).

PART	QUAN.	DESCRIPTION	MATERIAL





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2. FIELD			U.S. DEPARTMENT OF ENERGY ROCKY FLATS AREA OFFICE GOLDEN, COLORADO				
3. WEST		DESIGNED BELL					
4.		DRAWN SCHACKLIN	Rocky Flats Plant				
5.		CHECKED KRAESKI					
BLDG./FACILITY SITE		APPROVED	GOLDEN, COLORADO 80401				
ROOM/AREA WEST			OPERABLE UNIT 11 – WEST SPRAY FIELD ROCKY FLATS LOCATION MAP				
GRID COOR./COL NO. 749,000N 2,078,000E		SUBMITTED	SIZE	DRAWING NUMBER	ISSUE	SHEET	
MASTER YES ☐ NO ☒	SCALE: AS NOTED	APPROVED RFP APPROVED DOE	A	FIGURE 1–1	A	OF	

"COMPUTER–GENERATED: NO MANUAL CHANGES ALLOWED

PART	QUAN.	DESCRIPTION	MATERIAL

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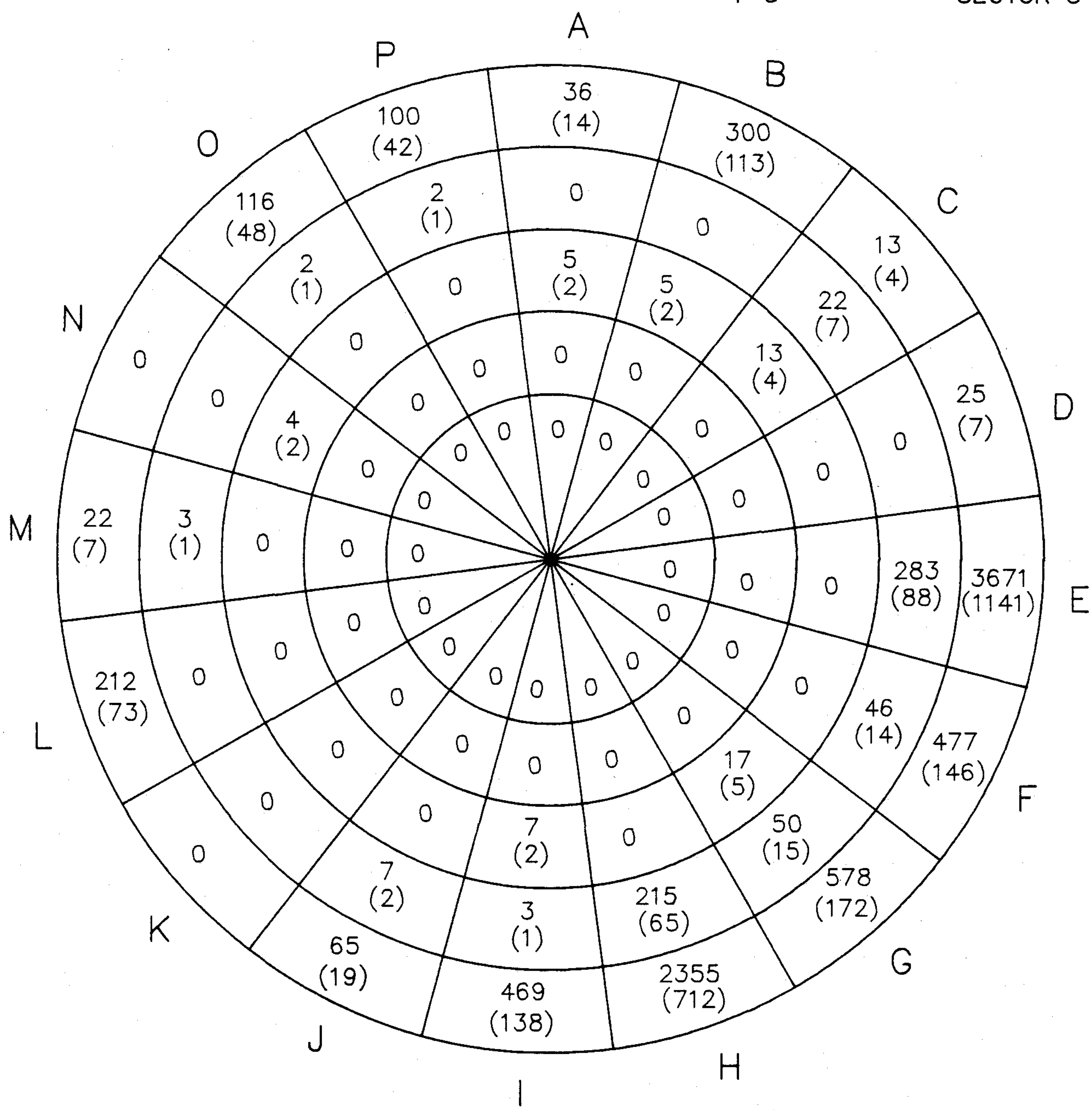
1–2	SECTOR 2
2–3	SECTOR 3
3–4	SECTOR 4
4–5	SECTOR 5



SOURCE: DOE,"1989 POPULATION, ECONOMIC AND LAND USE DATE BASE FOR ROCKY FLATS PLANT", (IN PRESS)

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BLDG./FACILITY
ROOM/AREA
GRID COOR./COL. NO.
DESIGNED
DRAWN LENNIE
CHECKED
APPROVED
SUBMITTED
APPROVED RFP
APPROVED DOE
MASTER YES ☐ NO ☒
SCALE: NONE

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant

GOLDEN, COLORADO 80401

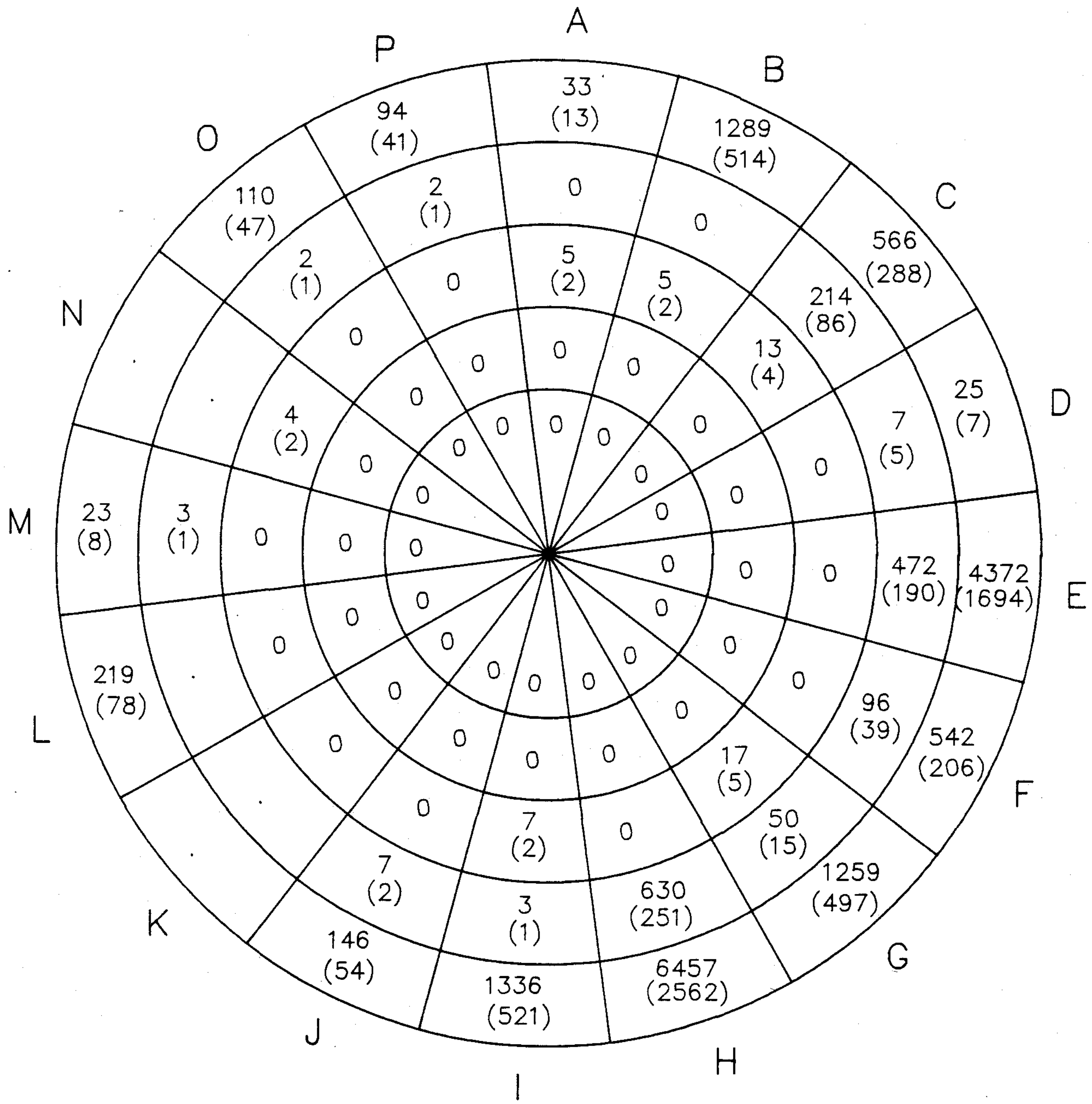
OPERABLE UNIT 11 – WEST SPRAY FIELD

1989 POPULATIONS & (HOUSEHOLDS)

SIZE	DRAWING NUMBER	ISSUE	SHEET
A	FIGURE 1-3	A	OF

PART	QUAN.	DESCRIPTION	MATERIAL

MILES	SECTOR NAME
0–1	SECTOR 1
1–2	SECTOR 2
2–3	SECTOR 3
3–4	SECTOR 4
4–5	SECTOR 5



SOURCE: DOE,"1989 POPULATION, ECONOMIC AND LAND USE DATE BASE FOR ROCKY FLATS PLANT", (IN PRESS)

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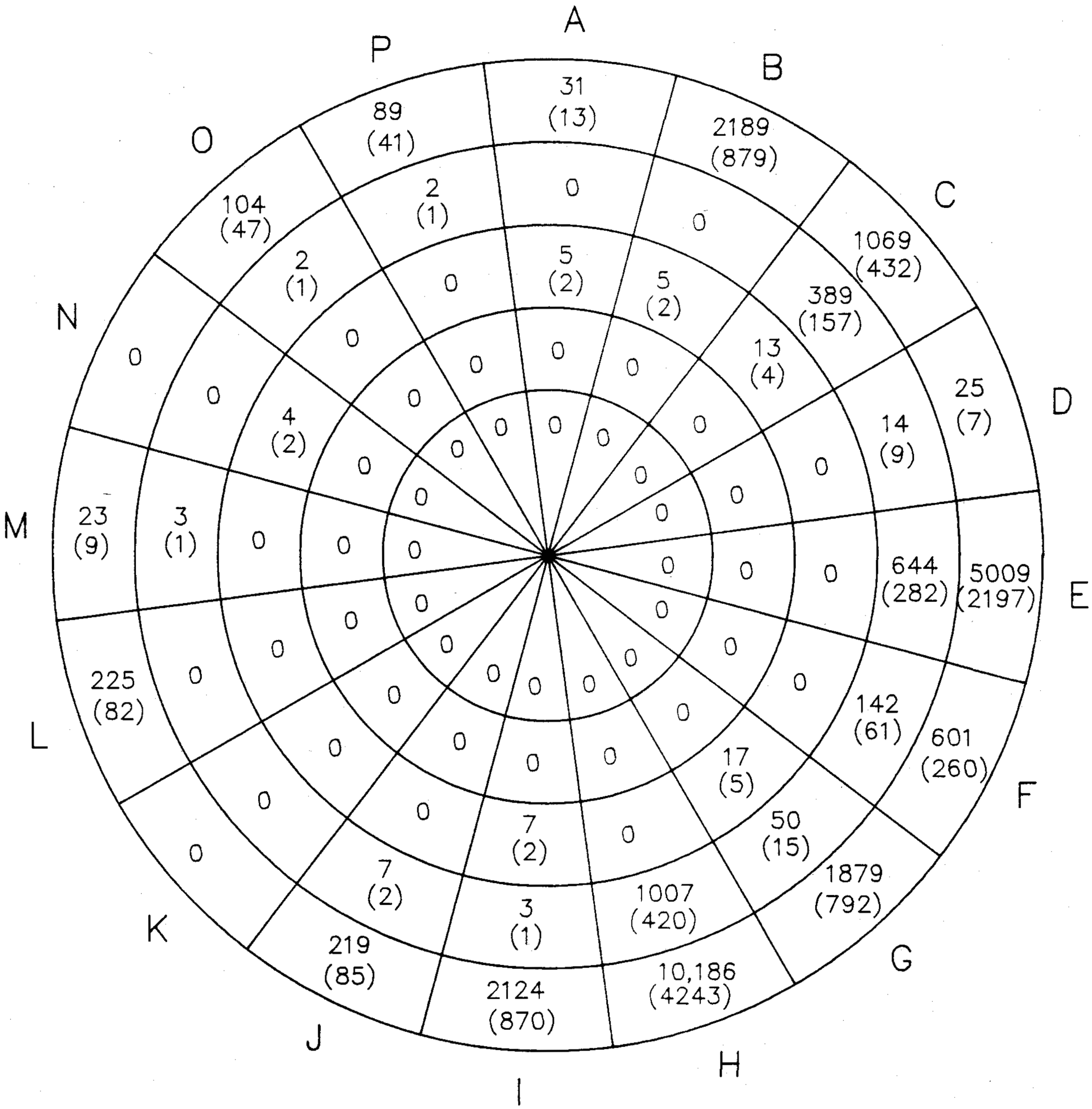
2.					
3.		DESIGNED		U.S. DEPARTMENT OF ENERGY ROCKY FLATS AREA OFFICE GOLDEN, COLORADO	
4.		DRAWN LENNIE		Rocky Flats Plant	
5.		CHECKED		GOLDEN, COLORADO 80401	
BLDG./FACILITY		APPROVED		OPERABLE UNIT 11 – WEST SPRAY FIELD	
ROOM/AREA				2000 POPULATIONS & (HOUSEHOLDS)	
GRID COOR./COL NO.		SUBMITTED		SIZE A	DRAWING NUMBER FIGURE 1–4
MASTER YES ☐ NO ☒	SCALE: NONE	APPROVED RFP / APPROVED DOE		ISSUE A	SHEET OF

"COMPUTER–GENERATED; NO MANUAL CHANGES ALLOWED"

PART	QUAN.	DESCRIPTION	MATERIAL

MILES	SECTOR NAME
0–1	SECTOR 1
1–2	SECTOR 2
2–3	SECTOR 3
3–4	SECTOR 4
4–5	SECTOR 5



SOURCE: DOE,"1989 POPULATION, ECONOMIC AND LAND USE DATE BASE FOR ROCKY FLATS PLANT", (IN PRESS)

KEYWORDS	A	ORIGINAL ISSUE				
	ISSUE	DESCRIPTION	DATE	RFP	DOE	CLASS / JOB NO.

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant

GOLDEN, COLORADO 80401

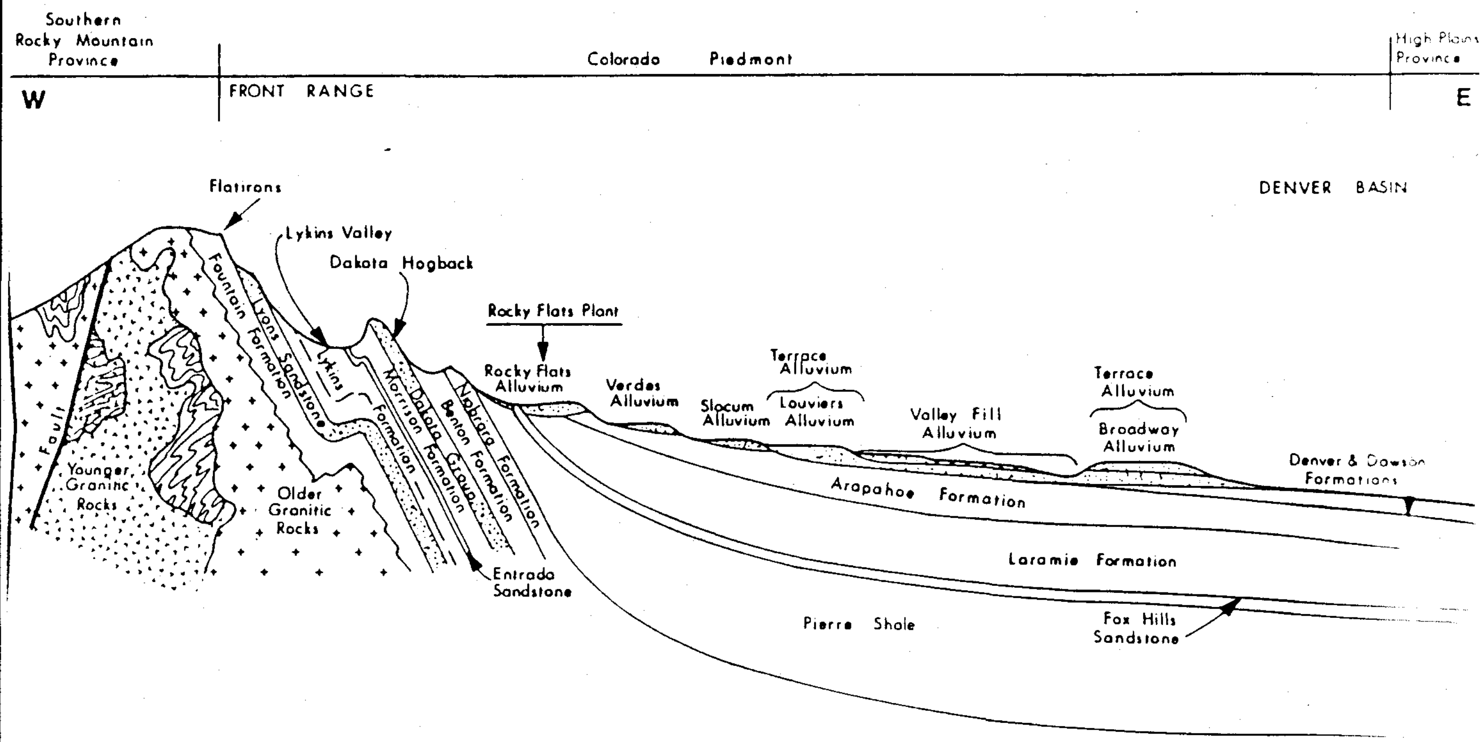
DESIGNED
DRAWN LENNIE
CHECKED
APPROVED

BLDG./FACILITY
ROOM/AREA
GRID COOR./COL. NO.

OPERABLE UNIT 11 – WEST SPRAY FIELD

2010 POPULATIONS & (HOUSEHOLDS)

MASTER	SCALE	SIZE	DRAWING NUMBER	ISSUE	SHEET
YES ☐ NO ☒	NONE	A	FIGURE 1-5	A	OF



KEYWORDS	A	ORIGINAL ISSUE			
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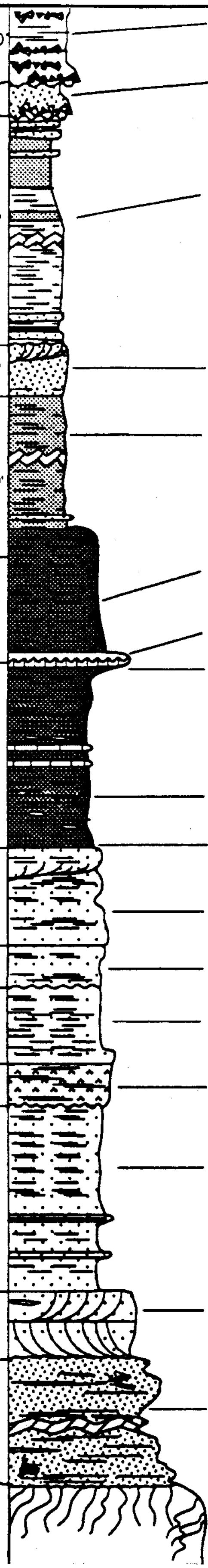
3.		DRAWN	LENNIE	**Rocky Flats Plant**	
4.		CHECKED		GOLDEN, COLORADO 80401	
5.		APPROVED		OPERABLE UNIT 11 – WEST SPRAY FIELD	
BLDG./FACILITY				REGIONAL GEOLOGIC CROSS SECTION	
ROOM/AREA		SUBMITTED		SIZE	DRAWING NUMBER
GRID COOR./COL. NO.		APPROVED RFP		A	FIGURE 1–6
MASTER YES ☐ NO ☒	SCALE: AS NOTED	APPROVED DOE		ISSUE	A

"COMPUTER–GENERATED: NO MANUAL CHANGES ALLOWED"

Age	Formation	Thickness	Description
Quaternary	Rocky Flats Alluvium	10'-50'	Poorly sorted, coarse, bouldery gravel in yellowish brown to redddish brown sand and clay matrix
Upper Cretaceous	Arapahoe Fm.	70'	Gray to yellowish orange sandy claystone and clayey sandstone, chert pebble conglomerate at base
Upper Cretaceous	Laramie Formation	650'	Gray, fine- to medium-grained sandstone and claystones; upper portion predominantly consists of massive claystones; thin coal beds in lower part; ironstone nodules
Upper Cretaceous	Fox Hills Sandstone	120'	Light olive gray to yellowish brown fine- to medium-grained cross-bedded sandstone, and laminated silty sandstone and shale at base
Upper Cretaceous	Pierre Shale	± 7500'	Dark gray, silty bentonitic shale and few thin, silty sandstones
Upper Cretaceous	Niobrara Formation	350'	Olive gray to dusky yellow, very calcareous shale, thin bentonite, gypsum, and fossiliferous limestone beds Light gray, dense, fossiliferous limestone
Upper Cretaceous	Benton Shale	450'	Yellowish gray, sandy fossiliferous limestone Dark gray shale with bentonite streaks, thin limestones in middle part Dark gray to black, brittle silty shale
Lower Cretaceous	Dakota Group: South Platte Formation	250'	Light gray, fine- to medium-grained cross-bedded sandstone, dark gray claystone in middle part
Lower Cretaceous	Dakota Group: Lytle Formation	100'	Light gray to tan, fine- to coarse-grained, locally conglomeratic sandstone, frequent red and green siltstone interbeds
Jurassic	Morrison Formation	250'	Gray to greenish-gray to red shale and siltstone, thin limestones in middle part; lenticular sandstones in upper and lower part
Jurassic	Ralston Creek Formation	110'	Light gray siltstone and light red, silty shale; calcareous; chert nodules and beds
Triassic / Permian	Lykins Formation	450'	Red siltstone and claystone with two laminated limestones in lower part
Permian	Lyons Sandstone	150'	Pinkish-gray, fine- to medium-grained, cross-bedded sandstone; conglomeratic lenses frequent
Pennsylvanian	Fountain Formation	800'	Red, fine- to coarse-grained sandstone and conglomerate, arkosic, thin, lenticular red siltstones frequent throughout
Precambrian			Gneiss, schist, and small granitic intrusions



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BLDG./FACILITY								
ROOM/AREA								
GRID COOR./COL. NO.								

DESIGNED
DRAWN LENNIE
CHECKED
APPROVED
SUBMITTED
APPROVED RFP
APPROVED DOE

MASTER YES ☐ NO ☒

SCALE: AS NOTED

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant

GOLDEN, COLORADO 80401

OPERABLE UNIT 11 – WEST SPRAY FIELD

REGIONAL STRATIGRAPHIC SECTION

SIZE	DRAWING NUMBER	ISSUE	SHEET
A	FIGURE 1–7	A	OF

2.0 SITE CHARACTERIZATION

This Section discusses the information available on the West Spray Field. The regulatory background leading to development of this Work Plan is summarized in Section 2.1. Information concerning the operation of the facility as well as the site geology and hydrology is presented in Section 2.2. Section 2.3 details the previous chemical characterizations of wastewater and the environmental media associated with the waste management unit. Background geochemical characterization efforts are also discussed. This information is utilized to develop the release mechanisms, migration pathways, and exposure routes presented in the site conceptual model (Section 2.4).

2.1 REGULATORY HISTORY OF OU11 AND INTERIM RESPONSE ACTIONS

The West Spray Field was identified as a hazardous waste management unit regulated by the Resource Conservation and Recovery Act (RCRA) in 1986 because it was known to have received water containing hazardous constituents from the Solar Evaporation Ponds. Because of this determination, a Closure Plan for the West Spray Field was required pursuant to Part 265 of the Colorado Hazardous Waste Regulations (6CCR) and Title 40, Part 265 of the Code of Federal Regulations (40 CFR). The first Closure Plan was prepared in August, 1986. This document was supplemented by a "RCRA Post Closure Care Permit Application," prepared by Rockwell International in September, 1988. This document not only discussed the West Spray Field, but other identified hazardous waste management units as well.

In July, 1986, a Comprehensive Environmental Assessment and Response Program (CEARP) and Compliance Agreement was finalized by the USDOE and the USEPA. This began a comprehensive program of site characterizations, remedial investigations, feasibility studies, and remedial/corrective actions. This program is currently known as the Environmental Restoration

(ER) program. As part of this program, preliminary assessments have been completed and have identified past on-site storage and disposal locations as potential sources of environmental contamination. A comprehensive study of site background soil, sediment, groundwater and surface water quality has also been completed.

On June 28, 1989, the State of Colorado and the USDOE entered into an Agreement in Principal (AIP). Certain contaminated sites, not including the West Spray Field, were identified in this document as requiring expedited cleanup in order to prevent ongoing releases of harmful contaminants.

On January 22, 1991, the USDOE, USEPA, and State of Colorado entered into a Federal Facility Agreement and Consent Order governing environmental response actions. This Order is also known as the Rocky Flats Interagency Agreement (IAG). This agreement outlines the work to be undertaken and work schedule for the RCRA Facility Investigation/Remedial Investigation (RFI/RI) and Corrective Measures Study/Feasibility Study (CMS/FS) response actions. This document provides a detailed Work Plan for the Phase I RFI/RI for the West Spray Field. Phase I activities include a characterization of the waste sources and potentially impacted soil.

2.2 BACKGROUND AND PHYSICAL SETTING OF OU11

2.2.1 Operational History of OU11

The descriptions of the West Spray Field in this section are drawn from the 1989 West Spray Field Closure Plan (Rockwell, 1988a). The terms "spray application" and "spray irrigation" are used interchangeably in the following text. These terms are used to describe the technique which was employed to evaporate wastewater at the West Spray Field.

The West Spray Field covers an area of approximately 4,577,000 square feet or about 105.1 acres. It consists of undeveloped acreage located on the west side of the Rocky Flats Plant.

The West Spray Field was operated from April, 1982 to October, 1985. During operation, excess liquids from Solar Evaporation Ponds 207-B North and 207-B Center were pumped periodically to the West Spray Field for spray application (Figure 2-1). Pond 207-B North received water from an interceptor system installed to collect groundwater seepage from the hillside north of the Solar Evaporation Ponds. Pond 207-B Center received treated sanitary effluent.

Spray application was conducted using various pieces of equipment in three areas within the boundaries of the waste management area. Spray application was initially performed using two moving spray irrigation lines mounted on metal wheels with stationary impulse heads in Area 1. These portable lines were replaced by the two western-most fixed lines shown in Area 1, and in 1985 by a third fixed irrigation line. These lines were fitted with stationary impulse heads. Area 2 was the location of a single fixed irrigation line. A spray impulse cannon was placed in various locations of Area 3 after use of the portable irrigation systems was discontinued (Shirk, 1986). These application areas are delineated on Plate 2-1.

The West Spray Field was used when excess liquids accumulated in Ponds 207-B North or 207-B Center. When the storage capacity of one of the ponds was reached, the liquids were pumped to the spray field for land application (Shirk, 1986). These ponds originally contained process wastewater. All process wastes were removed in the B-series Solar Evaporation Ponds 207-B North, Center, and South in the late 1970s, as detailed in the Solar Pond Closure Plan (Rockwell, 1988b). Since that time, the B-series Solar Evaporation Ponds have held treated effluent water from the plant wastewater treatment system and groundwater intercepted from an area north of the Solar Evaporation Ponds. The 207-B North and Center ponds receive liquid on a relatively constant basis due to the constant generation of treated sanitary wastewater which is still placed in 207-B Center, and relatively constant generation of groundwater collected north of the Solar Evaporation Ponds which continues to be placed in Pond 207-B North. The groundwater in this area is still collected because of elevated nitrates and the resultant need to prevent off-site migration of this groundwater. Although process wastewater was not held in the Evaporation Ponds from which water was pumped to the West Spray Field, it is possible that contaminants could have migrated from the ponds if they allowed any seepage during the period in which they contained process wastewaters. These potential contaminants would have been applied to the West Spray Field if they were captured by the groundwater Interceptor Trench System during the 1982-1985 time period.

2.2.1.1 General Location and Application Areas

Based on interviews with Plant personnel (Rockwell, 1988a), direct application of the liquids occurred in the portions of the spray field designated Areas 1, 2 and 3 (see Figure 2-1). This conclusion is supported for Areas 1 and 2 by examination of aerial photographs. However, the location of Area 3 is less readily confirmed by the aerial photographs due to limited use and various locations of application. The photographs also indicate some surface run-off occurred beyond the limits of Areas 1, 2, and 3. In addition, runoff beyond the boundaries of the Spray Field has been documented. Unknown quantities of windblown spray may have also contributed to the vegetation pattern observed on the aerial photographs (Rockwell, 1988a).

The total combined area of direct application is about 14.1 acres or about one-seventh of the total West Spray Field area. Area 1 is approximately 1,553,000 square feet or about 35.6 acres in size. This area contained both portable irrigation lines and three fixed irrigation lines. The fixed lines had a spray width of 80 feet and average length of 1,524 feet. This resulted in a spray area of approximately 8.4 acres for the three lines. Area 1 bounds the general area of application for the original portable irrigation lines. Figure 9-2 shows a current photo of a portion of Area 1.

Area 2 is approximately 1,360 feet by 80 feet in size with a surface area of 109,000 square feet or about 2.5 acres. This area corresponds to the estimated application area of a single anchored irrigation line which remained in one location. The remaining abandoned line can be seen in Figure 9-3, which shows a view from the south end of this line looking north.

Area 3 is an oval shape made up of small circular application areas all with a radius of approximately 100 feet, the estimated maximum radius of the impulse cannon. The source area is approximately 140,000 square feet or about 3.2 acres. A current view of Area 3, looking east, is shown in Figure 9-4.

2.2.1.2 Construction and Equipment Installation

The auxiliary equipment required to transfer the liquid from Ponds 207-B North and Center to the West Spray Field consisted of a pump at the Solar Evaporation Ponds, a delivery pipeline, the irrigation lines and an impulse cannon. The spray field was operated by one person at a time (Shirk, 1986). The approximate former locations of the irrigation lines are shown on Figure 2-1.

The pump was a portable, engine driven centrifugal pump installed on the separator dike between Ponds 207-B North and Center. The pump and propane-fueled drive engine were mounted on a trailer. The pump intake was a flexible hose which could be connected to either valve stub from Ponds 207-B North or Center. The pump discharged to a rigid pipe connected to the delivery line. The pump has since been removed for other use.

The delivery pipeline was initially a six-inch diameter PVC pipe. The PVC pipe extended approximately 900 feet from the pump discharge at Pond 207-B North beneath the patrol road, perimeter security zone and access road in a below-ground trench installation. The pipeline then emerged and was laid on the ground surface the remainder of the distance to the Spray Field. Where the pipeline crossed North Walnut Creek it was supported on roughly three-foot high stanchions. The entire pipeline extended approximately 6,000 feet to the West Spray Field. The pipeline was drained after operation through a valve at the low point of the line just above the Interceptor Trench Pump House. Liquids were drained into the pump house through a flexible hose.

The delivery pipeline was connected to the irrigation header pipe with a six-inch diameter flexible hose. The header pipe was a six-inch diameter aluminum pipe. At every other joint a four-inch diameter valved riser was installed which could be connected to irrigation lines. At the end of the header pipe was a plug and vacuum relief valve.

Initially, four-inch diameter portable spray irrigation lines approximately 1,300 feet in length were connected by flexible hose to the valve risers. The lines were attached to a ground anchor rod to prevent movement. The irrigation lines were equipped with fixed head impulse sprinklers for uniform application of the waters. Very soon after installation and prior to system startup, in November of 1981, the portable lines were damaged by wind. Additional incidents of wind damage caused the portable lines to be abandoned at the site with the exception of the single line presently located in Area 2. Subsequently, three fixed irrigation lines with lengths of between 1,350 and 1,570 feet were installed in Area 1 as shown on Figure 2-1. These lines consisted of fixed head impulse sprinklers for uniform application. A 125-gallon per minute spray impulse cannon with a flexible hose connection was placed in Area 3.

2.2.1.3 Application Volumes and Sources

The total monthly volume of liquids applied to the West Spray Field from Ponds 207-B North and Center are shown on Tables 2-1 and 2-2, respectively. Total application rates for the spray field were between 250 and 450 gallons per minute. For the spray irrigation lines, these total rates convert to maximum surface application rates of between about 20 and 40 gallons per minute per acre. These application rates are based on an average application area of 2.7 acres along each of four irrigation lines and 0.7 acres for the impulse cannon. The spray impulse cannon had a discharge of 125 gallons per minute for a surface application rate of about 179 gallons per minute per acre. The spray impulse cannon was moved over a total area of 3.2 acres.

Liquids from Pond 207-B North were primarily applied in Area 1. Generally, spraying from Pond 207-B North occurred in intervals of six to ten hours daily for periods of two to four days. As stated previously, Pond 207-B North received contaminated groundwater pumped from the Interceptor Trench System (ITS) during the operating period of the spray irrigation system. The ITS was installed in response to nitrate contamination of North Walnut Creek, documented in the early 1970s. A system of trenches and sumps were originally installed between 1971 and 1974. An additional control structure was constructed to capture contaminated water which drains from the footings of Buildings 771 and 774. These structures were in operation until replaced in the early 1980s by the ITS (U.S. DOE, 1991e). The ITS system collects groundwater and surface water north of the evaporation ponds in gravel-filled trenches containing perforated pipes. This water flows by gravity to the Interceptor Trench Pump House.

The water from the ITS that collects in 207-B North has been characterized (U.S. DOE, 1991e) as containing elevated nitrate, chloride, and sulfate. The most prevalent metals in this water are sodium, potassium, calcium, and magnesium. Radionuclide concentrations are highest for uranium-234 and uranium-238. The only organic compound detected is methylene chloride, although this compound was also noted in blanks.

Liquids from Pond 207-B Center were applied to all three application areas. Application periods for these liquids were similar to those for the 207-B North pond water (Shirk, 1986). The water present in Pond 207-B Center consisted of treated sanitary effluent from the Rocky Flats Plant sanitary wastewater treatment plant. This effluent was characterized by elevated nitrates, gross alpha and gross beta concentrations.

Based on the total volumes applied between April 1982 and October 1985 and the estimated areas of application of 8.4, 2.5 and 3.2 acres for Areas 1, 2 and 3, respectively, a total average was estimated. The estimated total application of Pond 207-B North water is about 40 inches of liquids applied in Area 1. The estimated total application of Pond 207-B Center liquids is roughly 150 inches, applied in Areas 1, 2 and 3. Since liquid from both ponds were applied in Area 1, the <u>maximum</u> total application could have been as much as 190 inches per unit area for all four years of operation.

2.2.2 Overview of Previous Investigations at OU11

Preliminary soil testing has been conducted to evaluate whether the soils in the West Spray Field are contaminated. Soil samples were collected during 1986 and 1988 to characterize the soil chemistry in the West Spray Field. The 1986 sampling program was conducted on a limited area inside the boundary of OU11. However, as shown in Figure 2-1, this area was not located in any of the areas which received direct application of liquids from spray heads or the impulse cannon. Eighteen locations from a maximum depth of one foot were composited into three samples for analysis. The samples were analyzed for metals, inorganic parameters, radionuclides, and volatile organic compounds. This sampling program gives an indication of the range of potential contaminant concentrations in areas not subject to direct spray application.

A more comprehensive sampling program was conducted in 1988 to characterize the entire spray field area. Twelve test pits were utilized to gather soil samples to a maximum depth of five feet. The locations of these test pits are shown in Figure 2-1. The 36 samples collected were analyzed for lead and mercury, other inorganic parameters, radionuclides, and volatile organic compounds. This data provides a much more comprehensive view of the nature of contamination in areas which were subjected to direct spray application, and areas of the field which received only windblown spray and surface runoff. With the exception of lead and mercury, the data does not provide comprehensive information on potential metals contamination. The sampling activities, analysis methods, data validity, and comparison with validated background data are presented in more detail in Section 2.3.2.

No comprehensive program of sediment or surface water sampling has been conducted to determine the nature or extent of contamination of these media which may have resulted from the spray application activities. Groundwater data upgradient of, downgradient of, and within the boundaries of the spray field have been collected through implementation of the RCRA groundwater monitoring program for OU11 (EG&G 1990a). The locations of the wells used to assess the impact of OU11 on the alluvial and bedrock aquifer are shown on Figure 2-1. These wells provide insight into the potential current impacts of the spray field activities on both the shallow alluvial aquifer and the unweathered sandstone aquifer. Details regarding the sampling activities, analysis methods, data validity, and comparison to validated background data for the two aquifers is presented in more detail in Section 2.3.3.

2.2.3 Interim Response Actions

Previous investigations of the West Spray Field have not indicated a need for an interim response action(s). No interim response actions have been initiated at the West Spray Field.

2.2.4 West Spray Field Geology

The following discussion of the geologic characteristics of the West Spray Field has been limited to the geologic formations present in the upper 200 feet of the stratigraphic column at the site. Site-specific information does not exist for older units, and it is not believed that they are relevant to the goals of this investigation. The formations included in this upper 200 feet are the Upper Cretaceous Laramie and the Quaternary Rocky Flats Alluvium.

Geologic information on these units has been obtained from the following sources:

- geologic logs of boreholes drilled during the installation of bedrock groundwater monitoring wells in or near the West Spray Field in 1986 and alluvial groundwater monitoring wells in 1989 (EG&G, 1991a);

- geologic logs of test pits installed at the West Spray Field (Rockwell, 1988a);

- surficial mapping of local geologic outcrops in 1986;

- Hydrology of a Nuclear-Processing Plant Site, Rocky Flats, Jefferson County, Colorado, U.S.Geological Survey, Theodore Hurr, 1976; and

- Phase II Geologic Characterization Data Acquisition, Task II, Shallow High Resolution Seismic Reflection Profiling, Indiana Street and West Spray Field, Draft Report, DOE, March 1991d.

2.2.4.1 Bedrock

Geologic logs of monitoring well boreholes which penetrate the bedrock at the West Spray Field and cross-sections constructed from those logs (Figure 2-2) indicate that the uppermost bedrock is the Upper Cretaceous Laramie Formation. The apparent absence of the younger Arapahoe Formation, present in other areas of the RFP, indicates that it was eroded prior to deposition of the Quaternary Alluvium in this area.

As described in Section 1.3.3.7, the Laramie Formation is approximately 800 feet thick and is subdivided into two major lithologic units: a lower sandstone unit and an upper claystone unit. Although neither unit appears to outcrop in the West Spray Field, both have been observed to outcrop to the west. Outcrops of the Laramie formation can be observed in the clay pits approximately 500 feet to the west of the West Spray Field. The upper claystone unit has been identified in the geologic logs of all wells in the West Spray Field that penetrate bedrock, but there has been no encounter with the lower sandstone unit.

Dip angles of Laramie Formation outcrops at the clay pits (shown on Plate 2-1 as "Active Mining Operation" range between 45 and 55 degrees with a dip direction of approximately N80^{0}E (Scott, 1960)). However, geologic logs of West Spray Field monitoring wells show that this dip angle quickly flattens out to the east, to approximately nine degrees beneath the West Spray Field.

These logs also indicate that the upper claystone unit consists of claystone with occasional zones of interbedded siltstones and sandstones. The lithology of this unit is described as follows:

- Claystones. Olive gray (5 Y 3/2) to dark gray (N 3/0), poorly indurated, silty, and contain up to 15 percent organic material. Weathering appears to have penetrated from 31 to 61 feet into bedrock, and the weathered claystones generally range from light olive gray (5 Y 5/2) to medium light gray (N 6/0) and medium gray (N 5/0) with moderate oxide staining of dark yellowish orange (10 YR 6/6). They are blocky, slightly fractured, and have iron staining as mottles and along bedding planes and fractures (Rockwell, 1986b). Occasional zones of sandstone or siltstone interbeds up to 0.5 ft. thick were also encountered.

- Siltstones. Weathered siltstone is typically medium light gray (N6/0) to light olive gray (SY 5/2) with stains and mottles of dark yellowish orange (10 YR 6/6) (Rockwell, 1988a). Siltstone thickness ranges from approximately one to eight feet with sandy siltstone or clayey siltstone interbeds of one to three inches thick. Iron nodules are occasional and fractures abundant from 99 to 104 feet near Area 2 and from 133 to 136 feet just west of Area 1 (Rockwell, 1988). Unweathered siltstone is typically medium light gray (N 6/0) to medium dark gray (N 4/0) and has approximately 0.25-foot thick beds of sandstones or claystone. Coal occurs occasionally and carbonaceous fragments are abundant (Rockwell, 1988a).

- Sandstone. Unweathered sandstone was encountered in two wells (46-48 and 48-86), at a thickness of 0.7 to 11.0 feet. It is moderately to poorly sorted, and very fine-grained to medium-grained calcite cemented. The sandstone may be silty or clayey with occasional thin laminae of fine silt and clay. Color typically ranged from medium light gray (N 6/0) to medium dark gray (N 4/0). The thin sandstone bed in well 46-86 at 126.9 to 127.6 feet was additionally described as dark greenish gray (5 GY 4/1) in color. Unweathered sandstone in well 48-86 occurred at 151.30 to 153 feet below ground surface and again at 197.0 to 208.3 feet below ground surface. It does not appear that these sands are deep enough to be part of the C Sand, unless significant erosion of the upper unit of the Laramie has occurred along with the erosion of the Arapahoe.

2.2.4.2 Surficial Geology

Five monitoring well boreholes (5086, 5286, 4886, B100889, and B110989) have penetrated the total thickness of the alluvial unit within the immediate vicinity of the West Spray Field. Geologic logs of these boreholes indicate that the surficial deposits at the West Spray Field range in thickness from 65 to 72 feet. Numerous other monitoring well boreholes have been installed within the alluvial materials to depths of 50 to 75 feet, but they did not fully penetrate the alluvial materials. The surficial deposits encountered included the Rocky Flats Alluvium and the Flatirons Soils.

A geophysical investigation using seismic reflection technology conducted across the western two-thirds of the West Spray Field (from approximately well 5286 to 4986) indicated that the contact between the bedrock and overlying alluvium was uniform in nature with no significant bedrock anomalies (DOE, 1991a). Also confirmed by the seismic survey was the relatively uniform nine degree dip angle of the Laramie Formation under the West Spray Field.

As described in Section 1.3.3.7, six distinct units of Quaternary unconsolidated surficial materials are present in the area surrounding the RFP. However, only the Rocky Flats Alluvium is present in the West Spray Field. This alluvium is topographically the highest and the oldest of the alluvial deposits (Figure 1-6). In the West Spray Field, it unconformably overlies the Laramie Formation.

Geologic logs of the West Spray Field wells indicate that the alluvium encountered is unconsolidated, and is composed of poorly sorted angular to subrounded cobbles, coarse gravels, coarse sands, and gravelly clays. Generally, deposits are reported to be coarser grained in the west, as would be expected given the depositional environment.

The Flatirons Soil overlies the Rocky Flats Alluvium and is a deep, well-drained, strongly developed soil composed of stony to gravelly and silty material (USDA, 1984). It typically occurs on high terraces and pediments. Permeability of this soil type is moderate and runoff erosion is not considered a hazard (Rockwell, 1988).

The A, B, and C horizons are present in the West Spray Field. These horizons were observed in test pits and described in geologic logs (USDA, 1984), which are summarized below:

- A Horizon. This horizon ranges from 1.1 to 1.35 feet in thickness (Rockwell, 1988). It is described as dusky brown (5 YR 2/2) gravelly, cobbly, sandy soil that is moist to wet. It is typically poorly to moderately sorted with subrounded and subangular fine-graded to coarse-graded gravels and occasional small cobbles. The contact with the underlying B horizon is wavy and sharp.

- B Horizon. This horizon extends from 1.1 to 3.5 feet below ground surface. It is a moderate brown (5 YR 4/4) clayey sand to clayey gravel with small zones of intense red and brown staining indicative of weathering. Sand is generally moderately sorted, subangular to subrounded, medium-grained to coarse-grained with occasional fine-grained pockets. Gravels are described as subrounded, fine-graded to very coarse-grained pebbles and small to large cobbles with occasional small boulders. Gravels and sands are indicative of a short transport distance. Clay occurs in the matrix but mostly in pockets associated with the gravel. The zone is generally moist to saturated. Some organic soil stringers from the A horizon were noted. The contact into the C horizon is irregular and gradational and occurs from 3.0 to 3.5 feet below ground surface (USDA, 1984).

° <u>C Horizon</u>. This horizon extends from 3.0 feet to 5.2 feet below ground surface. It consists of clayey to silty sands and gravel or gravelly sands. Colors range from light brown (5 YR 5/6) to moderate yellowish brown (10 YR 5/4) with zones of red, brown, orange or yellow staining. The sand is typically medium-grained, subangular to subrounded, moderately sorted, with some fine-grained and coarse-grained sands. Gravels are subrounded, moderately to poorly sorted, fine-grained pebbles to large cobbles with occasional small boulders. Clay zones of olive gray are commonly associated with the gravel and cobbles. The zone is generally moist with occasional saturated zones. Caliche stringers were encountered at 4.4 feet below ground surface in WSF-06.

2.2.5 West Spray Field Hydrogeology

Groundwater monitoring of the West Spray Area began in 1986 and is ongoing. Because the goals of this Work Plan are focused on characterization of the vadose zone, the hydrogeologic information obtained from this monitoring has been only briefly summarized herein.

° <u>Rocky Flats Hydrostratigraphic Unit</u>. The shallow groundwater system at the West Spray Field is within the Rocky Flats Alluviam described in Section 1.3.3.8. Geologic logs and water level data indicate that it is unconfined and is present in the Rocky Flats Alluvium. Given the weathered nature of the upper Laramie Formation beneath the West Spray Field, it is likely that the shallow system extends partially into this formation.

As discussed previously, the Rocky Flats Hydrostratigraphic Unit is recharged by infiltration of water from rain, snowmelt, and surface water sources, and discharge is reported to occur at springs and seeps at the alluvium/bedrock contact and in major drainages. Quarterly monitoring results indicate that the depth to water averages 40 to 50 feet across the Spray Field and varies seasonally by two to four feet (EG&G, 1991c). The highest water level elevations occur in spring, which is characteristic of the behavior of the aquifer in the general area of the RFP (Hurr, 1976).

Water table contour maps constructed with quarterly elevation data (Figures 2-3 through 2-6) indicate that the direction of groundwater flow in the shallow aquifer in the West Spray Field generally follows topography to the east or toward the off-site drainages. The hydraulic gradient across the West Spray Field is calculated at 0.009 to 0.013, which falls within previously determined ranges for the Rocky Flats Hydrostratigraphic Unit at the RFP (EG&G, 1991a). Elevation data for the pre-1986 monitoring wells was not presented in the <u>1990 Annual RCRA Ground Water Monitoring Report for Regulated Units at Rocky Flats Plant</u> report, thus, this data was not used in the preparation of these figures.

Horizontal hydraulic conductivity values calculated for this aquifer in the West Spray Field area range from 2.1 x 10^{-5} centimeters per second (cm/s) to 5.3 x 10^{-4} cm/s (3.5 to 87.8 feet per year), based on drawdown-recovery and slug tests performed on 1986 wells (Rockwell, 1988a) and slug tests performed in 1989 (EG&G, 1990a).

- Arapahoe Hydrostratigraphic Unit. Because the Arapahoe Formation appears to have been completely eroded in the West Spray Field (Section 2.2.4), the Arapahoe Hydrostratigraphic Unit, which is the upper bedrock water-bearing zone under much of the surrounding area (Section 1.3.3.8), is also absent.

- Laramie-Fox Hills Aquifer. The uppermost bedrock water-bearing zone at the West Spray Field appears to be the Laramie-Fox Hills Hydrostratigraphic Unit. This water-bearing zone is reported to be confined to the A and B Sands of the Laramie and the sandstones of the Fox Hills Formation by several hundred feet of the relatively impermeable upper shale unit of the Laramie (Section 1.3.3.8). However, in the area of the West Spray Field, the erosion of the Arapahoe Formation and portions of the underlying Laramie, may have reduced the thickness of this impermeable layer. Little, if any, hydraulic connection is believed to exist between the Laramie-Fox Hills aquifer and the overlying water-bearing zones (Hurr, 1976).

There are no monitoring wells on the West Spray Field which appear to be deep enough to potentially encounter the Laramie-Fox Hills Hydrostratigaphic Unit. Monitoring well 48-86, installed to a depth of 207 feet below grade, is screened in an 11-foot thick, water-bearing sandstone layer (197 to 208 feet below grade or 5879 to 5900 feet MSL), located between two siltstone layers. A 22-foot thick, water-bearing sandstone was encountered just west of the West Spray Field at location 52-86 (101-123 feet below grade or 6014 to 6041 feet MSL). These layers may be hydraulically connected, if not directly correlative. According to

Hurr (1976), the upper claystone unit may be up to 630 ft. thick, thus, the depth to the water-bearing lower sandstone unit may approximate this depth.

These water-bearing sandstones are likely to be part of the frequently occurring and thick sandstone layers described as being present in the upper claystone unit. It is unlikely that they are part of a continuous aquifer system, although they may be continuous enough to outcrop or subcrop, and be recharged west of the West Spray Field.

2.2.6 West Spray Field Surface Water Hydrology

There are no surface water bodies within the boundaries of the West Spray Field. However, numerous small, natural, drainage channels cross the site and serve to direct surface runoff to off-site surface water bodies. As discussed in Section 1.3.3.4, general topography slopes to the east and to stream drainages.

There is a very slight topographic high that appears to be less than five feet in relief and bisects the West Spray Field from east to west. On the north side of this topographic high, surface water primarily runs overland to the east; but, near the northern border of the spray field, it also runs northeast to the Walnut Creek drainage immediately north of the spray field. On the south side of the topographic high, surface water also primarily runs off-site to the east; but, near the southern boundary of the site there is some runoff to the drainage ditch paralleling the road. If this ditch overflows, runoff would be to the drainage of Woman Creek.

2.3 NATURE OF CONTAMINATION

2.3.1 Source Characterization

Liquids applied in the West Spray Field were derived from Solar Evaporation Ponds 207-B North and 207-B Center. Approximately 66,000,000 gallons of wastewater were applied at the West Spray Field during its operation. Of this quantity, approximately 9,000,000 gallons were taken from 207-B North, and 57,000,000 gallons were taken from 207-B Center (Rockwell, 1988a).

The contents in Pond 207-B North during operation of the West Spray Field generally consisted of groundwater collected in the trench interceptors and french drain system located in the hillside north of the Solar Evaporation Ponds (U.S. DOE, 1991e). The Interceptor Trench System (ITS) collected groundwater and has historically prevented seepage and groundwater recharge near the Solar Evaporation Ponds from entering North Walnut Creek. The liquid is piped to Pond 207-B North from the low point of the interceptor system, i.e. the interceptor trench pump house. Because the Interceptor Trench System collects groundwater downgradient of the Solar Evaporation Ponds, the recovered groundwater could possibly contain constituents which may have migrated from any of the ponds. As a result, the types of liquids and known contaminants identified in each of the Solar Evaporation Ponds are summarized briefly at the end of this source characterization.

The other source of wastewater which was applied to the West Spray Field was Evaporation Pond 207-B Center. The liquid contained in Pond 207-B Center generally consists of effluent from the Rocky Flats sanitary sewage treatment plant. However, some seepage contents from Pond 207-B North collected in the interceptor trench system have also been placed in Pond 207-B Center.

Sampling to characterize the waste composition of the liquids from 207-B North, 207-B Center, the interceptor trench pump house (ITPH) and the sewage treatment plant has taken place periodically from 1984 to 1988. During the period of 1984 to 1985, several indicator parameters were monitored on a weekly basis in the Solar Evaporation Ponds (U.S. DOE, 1985). These weekly analyses were conducted prior to the spray application of the liquids to the West Spray Field and included the following parameters: pH, nitrate (as nitrogen), gross alpha and gross beta. Two sets of metal analyses of Ponds 207-B North and Center liquids were performed in October 1984 and April 1985. The data from the 1984 and 1985 sampling efforts follows as Table 2-3. The last page of this Table provides a key to the various sampling programs which generated the data presented. The data suggest that the applied liquids contained slightly elevated concentrations of metals. The samples also exhibited elevated levels of nitrates, gross alpha, and gross beta.

The liquids from Pond 207-B North and the ITPH were also sampled in 1986, 1987 and 1988 (refer to Table 2-3). In the 1986 sampling, a few metals were identified above the detection limit but selenium was the only primary drinking water metal detected above the EPA Contract Laboratory Program (CLP) contract-required detection limit (CRDL). Gross beta and uranium were also detected in Pond 207-B North samples and in the ITPH liquid samples.

Various volatile organic compounds were detected in the liquid samples from the 207-B Ponds and the ITPH. Methylene chloride was detected in all three samples collected from Pond 207-B and ranged in concentration from 19 to 35 micrograms per liter (ug/l). It was also detected in two of the samples analyzed from the ITPH (10 and 15 ug/l). However, because methylene chloride was also present in the sampling blank at a concentration of 71 ug/l for the 207-B samples and at 99 ug/l for the ITPH sampling blank, these detections appear to be the result of laboratory contamination. Chloroform, carbon tetrachloride, and trichloroethylene were also identified in the liquid samples collected from the ITPH. Chloroform was present in two samples at 3 and 6 ug/l; carbon tetrachloride was found in three samples at 7, 6, and 7 ug/l; and trichloroethylene was detected in three samples at 7, 8, and 8 ug/l. These samples were gathered during specific sampling efforts, and volatile organic chemical analysis was not included in prior weekly or quarterly analyses.

Two sediment samples were collected from the ITPH during the 1986 investigation. Methylene chloride was the only volatile organic compound detected in the ITPH sediments (27 and 44 ug/kg). It was also reported in the sampling blank at 24 ug/kg and is, therefore, considered to be a laboratory artifact. Pesticides and PCBs were not found in the ITPH liquid and sediment samples. Semi-volatiles were not found in the ITPH and 207-B North liquids. Analysis of nitrates and radionuclides were not performed as part of the 1986 investigations.

In order to identify other contaminants which could possibly be present in the groundwater collected by the ITS, previous analyses of liquids and sludges in all of the Solar Evaporation Ponds were reviewed. The chemical constituents identified in these analyses could have been present in water applied to the West Spray Field only if these constituents were present in water which migrated from the ponds to the shallow water table and was collected by the ITS. According to a historical summary presented in the "Phase I RFI/RI Work Plan, Solar Evaporation Ponds, 1991," Pond 207-A contained process wastewater from 1956 until 1986, and was briefly used as overflow capacity to hold groundwater collected by the ITS in 1990. Ponds 207-B North, Center, and South contained process wastewater from 1960 until 1977. Since being cleaned out in 1977, the Center and South ponds have held treated sanitary effluent, treated water from the Reverse Osmosis Facility, backwash from the Reverse Osmosis Facility, and ITS groundwater. The North pond has been utilized for ITS recovered groundwater storage from 1977 until the present. The ITS water is not treated prior to being pumped to the north pond. Pond 207-C held process waste from 1970 until 1986. This pond has not been actively used since then. All of these ponds are lined to prevent releases of water to the subsoil.

Sample analysis results since 1983 in water and sludge in Pond 207-A were summarized in the 1991 OU4 RFI/RI Work Plan. Therefore, many of these samples represented process wastewaters formerly held in this pond, and may be indicative of the types of contaminants present in earlier process wastewaters. The inorganic analytes detected in these analyses included various radionuclides, beryllium, and cyanide. Organic compounds detected included the volatile compounds acetone and tetrachloroethylene, and the semivolatiles fluoranthene, di-n-butylphthalate, and bis(2-ethylhexyl)phthalate.

Ponds 207-B North, Center, and South have been sampled since the time they ceased being utilized for process wastewater storage in 1977. These analyses indicate levels of the nitrate, chloride, and sulfate anions as well as the sodium, potassium, calcium, and magnesium cations which are elevated over background levels for shallow groundwater and surface water (EG&G, 1990c). Various radionuclides and metals have been detected at low levels, with the most elevated radionuclide levels belonging to the uranium-234 and uranium-238 isotopes.

Because the 207-C Pond also held process waste until 1986, analysis of the liquid and sludge from this pond could also indicate contaminants potentially recovered by the ITS and transferred to the West Spray Field. Past analyses have detected high nitrate and cyanide concentrations as well as elevated levels of cadmium, chromium, copper, and nickel. The radionuclides present included americium, plutonium, uranium, and tritium. The only organic compounds reported in the OU4 RFI/RI Work Plan were acetone, and the pesticides diazinon and simazine.

2.3.2 Soil

This section presents an overview of the previous investigations conducted to assess soil contamination associated with the West Spray Field. The investigations summarized include both on-site and background evaluations. Sample locations, analysis parameters, and data validity are discussed and an overview of any remaining data gaps is presented.

2.3.2.1 History of Known Releases at OU11

As discussed in Section 2.1, the West Spray Field was operated from April 1982 to October 1985. The total application of liquid from Pond 207-B North and 207-B Central to the West Spray Field during its period of operation was calculated to be 9,000,000 and 57,000,000 gallons, respectively.

2.3.2.2 Previous Soil Sampling Activities at OU11

The 1986 sampling of the West Spray Field was an attempt to identify the extent, if any, of contamination. Nine locations were sampled. The X and Y coordinates for sampling locations were chosen within a 400 foot diameter area using a random number table. At each location, a surface scrape was collected using a disposable plastic scoop. In addition, two subsurface samples were collected from each location; one from 0-6 inches and one from 6-12 inches below ground surface using a split tube sampler driven with a sledge hammer to the desired depth. Each sample interval from all of the sampling locations were then composited resulting in three composite samples from the three depths. The 1986 sampling plot was not in an area of direct spray application but was affected in spots by surface runoff and possibly windblown liquids. At the time of sampling, it was believed this area received application from the spray impulse cannon in the West Spray Field. Information obtained subsequent to sampling and testing indicated the sample area was only affected by surface runoff, and perhaps windblown spray from application in Area 1. Table 2-4 lists the 1986 soil sampling parameters for the West Spray Field and samples collected from the Buffer Zone to be used as background samples.

In 1988, 12 test pits (WSF-01 to WSF-12) were excavated with a backhoe and three soil samples were collected for chemical analyses from each location at varying depths. Table 2-5 lists the 1988 soil sampling parameters for the West Spray Field Test Pits. The analytical data from both the 1986 and 1988 sampling programs are discussed in Section 2.3.2.4.

The soil sampling conducted to date in the West Spray Field provides a general idea of the types and levels of contamination which may be present in the West Spray Field soils. These general findings, including a discussion of laboratory contamination, are addressed in this section.

2.3.2.3 Development of Background Soil Chemistry Information

Background metals and radionuclide concentrations in soils have been developed from two sets of samples. An area the same size as that used to collect the 1986 soil samples was used to gather background samples and generate one set of data. A more comprehensive, site-wide background characterization was conducted in 1989 and published in 1990.

The 1986 background sampling and analysis was conducted in the west buffer zone (Figure 2-1) (Rockwell, 1988a). The top one foot of soil (Rocky Flats Alluvium) west of the West Spray Field was sampled. Eighteen locations were pooled into three composite samples (consisting of six cores randomly selected). The same methodology that was used to select the sampling locations for the previously mentioned 1986 background study was used for this sampling activity (Rockwell, 1988a). This sampling is not considered a complete characterization of background alluvial and bedrock materials, however, it serves as a basis for assessing potential contamination.

The 1989 sampling was performed as part of the Rocky Flats background geochemical characterization study. According to this study (Rockwell, 1989) samples were collected from nine borings in the Rocky Flats Alluvium. Samples from the alluvium materials were collected from the plant's southwestern and northern buffer zones. These boring locations are illustrated in Figure 2-7.

Split-spoon samples were collected to total depth in each borehole. A three-foot composite sample was collected at the surface of each borehole. Rocky Flats alluvium samples had six-foot composites collected three feet below ground to the alluvium/bedrock contact (unless a lithologically distinct layer greater than two feet was encountered). Seventy samples were collected from the alluvium.

Table 2-6 summarizes metals and radionuclide background values determined from this study. A separate off-site investigation is being conducted to verify the background concentration range of plutonium in surficial soils (Rockwell 1989). The mean and tolerance values obtained from the 1989 study are generally similar to the values determined from the 1986 background study.

2.3.2.4 Soil Sample Analysis Results

Metals

The soil samples collected in the West Spray Field during the 1986 sampling were analyzed for the metals listed in Table 2-7. Review of the metals data from the 1986 soil sampling effort indicates slightly elevated concentrations of arsenic, lead, manganese, and zinc (Table 2-7). Arsenic occurred at concentrations of up to 9.2 mg/kg in the surface scrape samples. Lead was also reported slightly above the mean background value (8 mg/kg) in several samples. Most of the samples contained manganese at levels higher than the upper tolerance interval (235 mg/kg) determined from the background data. Zinc was also elevated above the mean background value (24.2 mg/kg) in most samples.

Soil samples collected in 1988 from the West Spray Field test pits were analyzed for lead and mercury. These metals were chosen because previous analyses had shown them to be present in the spray application liquids. Mercury was not reported above background in any sample analyzed from the 1986 sampling effort. However, mercury was present in six samples collected in 1988 from the test pits above the background detection value of 0.15 mg/kg (Table 2-8). The values ranged from 0.20 to 0.46 mg/kg. In addition, eight samples exhibited concentrations above the background detection limit value of 0.1 mg/kg but were estimated values since they were below the laboratory detection limit. These detection limit values range from 0.12 to 0.18 mg/kg. Although mercury consistently appeared in the 1988 soil samples above the background detection limit standard, there does not seem to be a pattern relating the mercury concentrations to a particular depth or area since mercury was reported in all but two of the test pits and the depths from which the samples were collected ranged from 0.9 feet to 4.6 feet. Lead was reported above the mean background concentration of 8 mg/kg in every sample from the test pits.

Radionuclides

Radionuclides are analyzed by counting particles which are randomly emitted during radioactive decay. The rate of decay per unit time is more precisely determined for the material as the counting period increases. Because actual samples are counted for finite periods of time, there will always be uncertainty associated with any measured value. Radionuclide concentrations are thus reported as a measured value plus or minus a two standard deviation counting uncertainty (error term). This uncertainty is indicated in parentheses immediately following the measured value.

A determination that two radionuclide concentrations are different from each other requires a statistical analysis incorporating this uncertainty. Because of the significant overlap of the probability distributions, radionuclide concentrations with error terms larger than their respective measured value are not considered statistically different from the background values. If the measured value for a radionuclide falls within the measured background range, it is not considered to be above background levels regardless of the error term. This is the basis for stating that radionuclide concentrations are within background ranges. Similarly, if the measured sample value minus the error term is greater than the measured upper limit background value plus the corresponding error term limit of the background range, it can be considered to be statistically different from background. This leaves a range of measured values and error terms for which it cannot be definitely stated whether the radionuclide concentration in the sample is different from background. Even if a value in this range were determined to be different from background, it would be extremely low.

The radionuclide results from the 1986 soil sampling program (Table 2-9) have been compared to background levels summarized in Table 2-6, which were developed in 1989. Levels of gross alpha were consistently above the upper tolerance interval in the surface scrape samples but appeared to agree with background levels at 6-12" depth. Gross beta does not exceed the upper tolerance interval, but every valve is higher than the background mean of 23.5. Other species consistently above the upper tolerance interval include: plutonium, uranium-233, -234, and uranium-238.

Levels of uranium-233, -234, uranium-238, and plutonium were found above the background levels to which the 1988 test pit soil samples were compared (Table 2-10). Plutonium concentrations were reported above background ranging in concentration from 0.37(0.06) to 0.59(0.06) pCi/g. The highest concentrations are generally at the surface which indicates that plutonium was a constituent of the water applied in this area and was rapidly attenuated from further migration. The specific source of the plutonium, however, is unknown as previous analyses of the applied wastewaters have not shown the presence of plutonium. This trend is not observed in the uranium species.

Nitrate

Nitrates were not analyzed in the 1986 soil samples. However, soil samples collected from the test pits in 1988 were analyzed for nitrate (as nitrogen) (Table 2-11). All of the samples exhibited concentrations well above the background mean (9 mg/kg). There appears to be no distinct pattern correlating concentrations of nitrate with depth. The samples containing the higher concentrations were collected from various depths within the pits.

Organics

Several Hazardous Substance List (HSL) organics were found in soil samples at concentrations above detection limits. Although these results could be indicative of contamination, they could also be the result of laboratory contamination. Generally, indication of possible laboratory contamination is provided by comparison with laboratory blanks but no analyses for laboratory blanks were included with the volatile organics analytical results for the 1986 soil samples and 1988 test pit soil samples. Therefore, it is not possible to evaluate for certain whether the detected concentrations of acetone, methylene chloride, trichloroethene, chloroform, carbon disulfide, toluene, 1,1,1-trichloroethane, and 1,1,2-trichloroethane are laboratory contaminants. However, inspection of the data in Tables 2-12 and 2-13 indicates that volatile organics are generally near or below detection limits. In most cases, concentrations of the organic compounds are estimated below the detection limit.

2.3.2.5 Overview of Additional Soils Data Required

In order to adequately characterize the vadose zone soils in the West Spray Field, sampling locations must include a statistically significant number of samples in: the areas which received direct spray applications (Areas 1, 2, and 3 shown on Figure 2-1), the areas impacted regularly by surface runoff (the channel features shown on Figure 2-8, and the areas which are likely to have received no application, windblown spray, and/or occasional surface runoff. This was not achieved in either the 1986 or the 1988 soil sampling programs. The 1986 sampling area included two channels which regularly carried runoff as seen in the 1986 aerial photograph. The remainder of the sampling area would have received only occasional windblown spray and/or surface runoff. In addition, because the sampling was conducted in one area, it may or may not be completely representative of the entire OU area. Because of the variability in windspeed at the site and operating hours of the spray irrigation system, the extent of area impacted by windblown spray cannot be accurately estimated. Data analysis of future sampling in areas not subject to direct application can be used to estimate the change in concentrations with distance from the direct application areas.

The twelve test pits excavated in 1988 attempted to sample soils in all three former direct application areas, runoff channels, and occasionally impacted areas. The locations of testing in comparison with these various areas are shown in Figure 2-1. As a result, the data gathered in the soils to a depth of five feet should be representative of the site as a whole for the parameters measured. However, the only metals analyzed for in this program were lead and mercury.

The other requirement for vadose zone characterization is acquiring samples throughout the depth of the vadose zone. Neither historical characterization acquired samples from any depth greater than five feet. Because of the tendency for metals and radionuclides to attenuate rapidly with depth by adsorption onto soil particles, it is unlikely that these materials are present at levels of concern at greater depths if not present at levels of concern in shallow soils. Confirmatory sampling at depths greater than five feet to the maximum depth of the vadose zone will be needed if contamination is found in the shallow soils.

The quality and useability of the data presented in this Section is summarized in Section 4.1.2. Future sampling to be conducted to remedy the current data deficiencies is discussed in detail in Section 6.3.

2.3.3 Groundwater

This section describes the investigations to date which have developed groundwater data for the waters potentially impacted by OU11 activities, and for background water quality. Although investigation of groundwater impacts is scoped as a Phase II activity, the historic data is presented here as a means of summarizing data on all environmental media at the site prior to introducing Data Quality Objectives or details of future sampling. The sufficiency of existing groundwater data will be evaluated in the Phase II RFI/RI Work Plan.

2.3.3.1 History of Known Releases at OU11

Due to the nature of the activities at the West Spray Field, the potential impacts on groundwater would be the result of downward flow of surface-applied wastewater through the Rocky Flats alluvium to the alluvial aquifer. The impact could range from increased recharge to the addition of inorganic, radionuclide, and/or organic chemical contamination.

2.3.3.2 Previous Groundwater Sampling Activities at OU11

As a RCRA regulated unit at the Rocky Flats Plant, the West Spray Field has been subject to regular and ongoing groundwater monitoring since 1986. Currently, six monitoring wells are screened in the Rocky Flats Alluvium within the boundaries of the West Spray Field waste management area. These wells are numbered 0582, 0682, 4986, 5086, B411289, and B411389. An additional six alluvial monitoring wells are located along the boundary of the waste management area and are numbered B410589, B410689, B410789, B110889, B110989, and B111189. Three other alluvial wells are located upgradient of the West Spray Field based on topography and hydraulic gradient, and have historically been used for background measurements. These wells are numbered 1081, 5186, and 0782. The final location of monitoring wells is downgradient from the waste management area. This water quality is characterized using wells 0981, 4586, 4786, and 5086. The locations of the wells are shown on Figure 2-1. These wells are sampled quarterly and the results of sampling are documented in an annual report.

Bedrock water quality in the area of the West Spray Field is determined by sampling wells 5286, 4886, and well 4686. These wells are completed in unweathered sandstone. Well 5286 is located immediately west of the unit boundary; well 4886 is located on the east edge of spray area 2, and well 4868 is north of the unit boundary potentially downgradient from spray area 1. These well locations are also shown on Figure 2-1.

2.3.3.3 Development of Background Groundwater Chemical Properties

An investigation of the background water quality for the various hydrologic units at the Rocky Flats Plant was presented in the <u>Background Geochemical Characterization Report for 1989</u> (EG&G, 1990c). This report includes the raw data and statistical reduction of information from wells at various locations judged to be appropriate for background measurements. Because the West Spray Field is located on Rocky Flats Alluvium over bedrock of the Laramie Formation, the wells which develop background characteristics for the alluvium are used for comparison with alluvial wells associated with OU11. Bedrock wells completed for this study which are screened in unweathered sandstone are used for comparison with the results of bedrock wells associated with OU11.

Groundwater in the Rocky Flats Alluvium was characterized in the Background Characterization study by completing eight new wells and sampling these and one existing well. The wells are numbered B400189, B400289, B400389, B400489, B200589, B200689, B200789, B200889, and B405586. The wells are located in two groupings, one in the buffer zone north of the main plant, and one in the southwest portion of the buffer zone. These wells are located and identified in Figure 2-7. The southwest group was intended to characterize the alluvium typical of the West Spray Field. As part of the statistical data reduction, the populations of analyte concentrations were compared for these two groups to note statistically significant similarities and differences in the alluvium as a whole.

The Background Geochemical Characterization Report data indicated that the concentrations of the various inorganic species and radionuclides were not statistically different in the southwestern buffer zone well samples versus the northern buffer zone well samples. This was true for all parameters except the concentration of chloride. This conclusion is important because potentiometric surface maps of the West Spray Field and northern buffer zone indicate that one or more of the background wells could be impacted if contaminants reached the alluvial groundwater beneath OU11 and were transported downgradient. The lack of a statistical difference between the two sets of background wells indicates that OU11 is not impacting these wells. Several possible reasons for this include: OU11 is not contributing contaminants to the groundwater, dilution and attenuation have reduced potential contaminant concentrations to within background ranges, potential contaminants migrating from the Spray Field area have not reached any of these background wells, or there is not actually a hydraulic pathway from the spray field area to any of these background wells. The reason for the apparent difference in chloride concentrations between the two groups is not known.

Based on the statistical conclusions reached in the Background Characterization Report, the reduced data tables reported for the two groups of alluvial wells as a whole are used to compare to the data from alluvial wells associated with OU11. These data tables are included as Table 2-14.

Background bedrock water quality has been assessed by completing twenty-one wells into three types of bedrock materials: weathered claystone, weathered sandstone, and unweathered sandstone. The Background Characterization Report concluded that the analyte concentrations were statistically different between each of the various lithologies in which the various wells were completed. As a result, the only background bedrock water quality data which can be compared to bedrock water quality data is that which is obtained from wells completed in the same lithologic unit as the OU11 wells. The bedrock monitoring wells in the area of the West Spray Field are completed in unweathered sandstone of the Laramie formation. As a result, the three wells in the Southern Buffer Zone and the six wells in the North Buffer Zone which were completed in the unweathered sandstone were used to assess background water quality in the bedrock aquifer. The south wells are numbered B304289, B304989, and B405289. Wells B203789, B203889, B203989, B204089, B204189, and B204689 are located in the North Buffer Zone. A summary of the bedrock water quality information is reproduced from the 1989 groundwater monitoring report as Table 2-15.

2.3.3.4 Groundwater Sampling Analysis Results

The most recent compilation of alluvial and bedrock groundwater analysis results was presented in the Final 1990 RCRA Groundwater Monitoring Report (EG&G, 1991c). The 1990 results indicate that two upgradient wells immediately west of OU11 (well 5186 and well 1081) have been contaminated by nitrate. This may be the result of proximity to the direct spray application Area 1 or groundwater gradient changes resulting from past dewatering of the gravel/clay pits west of the site or recharge from the site.

Wells within the Spray Field boundary showed sporadically elevated levels of some analytes. Nitrate was only detected in well 4986 within the Spray Field boundary. Aluminum, copper, iron, and zinc have been sporadically detected in several wells within the Spray Field boundaries. Detectable levels of these metals are possibly the result of groundwater contact with native sediments and rock. Sodium, sulfate, and chloride are slightly, but consistently, elevated in wells 0582 and 4986.

There are six alluvial wells located along the perimeter of the West Spray Field area. Manganese was detected in wells B410589, B410689, and B410789. Radionuclides detected within the unit boundary included Tritium (well B410589), Americium-241 (well B410689), and Cesium-137 (well B110989). Plutonium-239 was detected in wells B410589 and B111189.

Well 4856 provides an indication of water quality downgradient of the West Spray Field from the wells located within the unit boundary. Samples from this well contained detectable levels of americium-241 and tetrachloroethylene.

The conclusions reached in the 1989 Annual RCRA Groundwater Monitoring Report (EG&G, 1990a) are that alluvial groundwater quality was affected sporadically by several metals, radionuclides, nitrate, and tetrachloroethylene. The ongoing RCRA monitoring results have been compared to the data developed and presented in the draft Background Geochemical Characterization Report (EG&G, 1990c) submitted to the regulatory agencies December 15, 1989. The data has not been compared to the information published in the final geochemical characterization report. The general conclusions indicated by the data are discussed in this section. The overview presented here is not intended to be an exhaustive statistical comparison of the background groundwater quality and the site groundwater quality, but rather to serve as an introduction to determine if a representative amount of data is being collected from proper locations and if additional data is required.

The upgradient alluvial wells yielded several samples higher than background levels for nitrate. Within the West Spray Field, the alluvial wells yielded samples above background for aluminum, copper, iron, sodium, zinc, chloride, and sulfate. Radionuclides and volatile organic compounds were not reported to be elevated above background. Water quality at the unit boundary and downgradient exhibited elevated levels of sodium (well B110989), magnesium (well B410589), manganese (well B410589), strontium (wells B410589 and B410689), and chloride (wells B410589 and B410789). Downgradient well 0981 exhibited elevated levels of chloride, sulfate, sodium, and strontium. Iron and aluminum were elevated in downgradient well 4586.

Two of the three bedrock wells have occasionally exhibited above-background concentrations of magnesium, strontium, and manganese. The radionuclides and volatile organic compounds were not elevated, nor were any analytes elevated in well 5286 above background.

2.3.3.5 Overview of Additional Groundwater Data Requirements

A sampling program for alluvial and bedrock groundwater will be developed as a Phase II activity. However, for purposes of completing the discussion of existing investigations of the environmental media at OU11, the existing groundwater information has been summarized. Based on the quantity and useability of the currently available data, the existing network of on-site and background wells in both the Rocky Flats Alluvium and unweathered sandstone bedrock appears to provide a representative and statistically significant data set of measurements. This data set allows statistical comparison of contaminant levels. The various wells are also positioned upgradient of application areas, within application areas, and downgradient of application areas in locations which should respond to migration of chemical constituents from the source areas. A detailed determination of the need for additional data will be presented in the Phase II OU11 RFI/RI Work Plan. The background wells drilled in the North Buffer Zone, especially the alluvial wells, could conceivably be impacted by flow from the West Spray Field, based on published potentiometric surface maps (Rockwell, 1988a) An ongoing comparison is planned to verify that the cluster of background wells in the North Buffer Zone yields statistically similar background values to those generated from wells in the Southern Buffer Zone.

2.3.4 Surface Water

The following paragraphs provide a summary of surface water sampling which has been conducted, either as an investigation of releases from OU11 or background surface water quality.

2.3.4.1 History of Known Surface Water Releases

The entire volume of water discharged to the West Spray Field was a surface release. The intent of the spray application design was to achieve one-hundred percent infiltration into the porous soil and alluvium at the site. However, complete infiltration was not achieved on a continual basis. As the soil and alluvium became saturated by continued periods of application, or if rain or snowfall had already partially saturated the site, surface runoff was induced. Largely this was confined to shallow drainage patterns within the unit boundary. Several of these drainages can readily be seen on aerial photographs and are visible on Plate 2-1 and Figure 2-8. On several occasions, surface water runoff was not confined to the unit boundary and flowed into the Walnut Creek drainage system. In June, 1982, the combination of heavy rains and spray irrigation led to observations of running water which entered the West Diversion Ditch and flowed into Walnut Creek. The quantities of this flow, chemical characteristics, and resulting stream concentrations in Walnut Creek are not known. This occurrence was again noted in December of 1982. Spray water was found to be draining toward Walnut Creek from the Spray Field. The immediate response was to dam this flow, and relocation of parts of the system was proposed. Again, the volume and chemical characteristics of the water which entered the Walnut Creek drainage is not known. No subsequent information was located detailing any resultant system modifications. Surface water flows again reached Walnut Creek in January, 1983. This event was noted as being comprised of water from Pond 207-B North.

A well-documented surface water flow event occurred in October, 1984 (Rockwell, 1984b). In the week following a snowstorm, a total of 929,000 gallons of water was released to the Spray Field. The nitrate level of the last 563,000 gallons of this water had been determined to be roughly 560 milligrams per liter. The runoff water from the spray irrigation area flowed to Walnut Creek via McKay Ditch. Measurements of water nitrate level were conducted on samples gathered from Walnut Creek at Indiana Street. These measurements peaked at 2.5-10 milligrams per liter. In response to this event, an internal policy was proposed to discontinue spray irrigation following a heavy rainfall or snowfall. A NPDES Violation Report to the EPA and Colorado Department of Health mentioned that a two-foot trench had been dug around the irrigation area. This trench is visible on subsequent aerial photographs on the north and east sides of the irrigation area, and can be seen on Plate 2-1.

2.3.4.2 Previous Surface Water Sampling at OU11

With the exception of the sampling described above in response to surface water flow off of the boundaries of the waste management unit, no surface water sampling information is available.

2.3.4.3 Development of Background Surface Water Chemical Properties

The 1989 Background Characterization Report developed data for several surface water stations across the plant site. Eleven surface water monitoring stations were selected which were upstream of all sites and units. Five stations were located in Woman Creek and tributaries. Two were located in tributaries of Walnut Creek, and four stations were located along the Rock Creek drainage. Sampling was attempted at each station during all four quarters of 1989, but several stations were dry during the summer and early fall. Analysis results for these samples did not indicate any obviously contaminated locations which would jeopardize the validity of use as background data.

2.3.4.4 Overview of Additional Data Requirements

Because spray irrigation is no longer performed at OU11 and there are no resulting surface water flows induced by activities at the West Spray Field, it is more appropriate to sample sediment in the drainages known or likely to have been impacted by past activities. A program of surface water sampling is made more difficult because there are no perennial flows within the boundary of OU11. No additional surface water sampling is planned.

2.3.5 Sediment

The potential impacts to sediment are discussed in the following paragraphs. Previous on-site, off-site, and background sampling and analysis programs are summarized.

2.3.5.1 History of Known Releases to Sediments

Several locations of potentially impacted sediment are known from past events of surface water flow from the spray application areas and from aerial photographs. Sediment in these drainages could be impacted as a result of deposition of particles containing adsorbed contaminants, or direct adsorption of contaminants dissolved in the surface water runoff. The drainages both within and outside the waste management unit boundary which could be impacted as a result of known surface water flows are highlighted in Figure 2-8. These drainages include those surface water flows inside the unit boundary, the trenches dug around the West Spray Field and visible in the aerial photograph, McKay Ditch, and North Walnut Creek to Great Western Reservoir.

2.3.5.2 Previous Sediment Sampling Activities at OU11

No sampling and analysis program designed to delineate the quality of sediments associated with water runoff from the application areas has been conducted. It is possible that the 1986 sampling obtained sediment samples in the surface scrapes that were gathered, but these were not separately noted or analyzed.

2.3.5.3 Development of Background Sediment Chemical Properties

Ten sediment stations paired with surface water sampling stations were sampled in order to characterize the background sediment quality. The locations of these samples appear unlikely to have been impacted by activities at the West Spray Field or other site activities (EG&G, 1990c and 1991d). Each location was sampled twice in 1989. The results of the analysis did not indicate any obvious contamination which would jeopardize use of the results as background data.

2.3.5.4 Overview of Additional Data Requirements

As an extension of the soil sampling plan for OU11, sediment data will be necessary to assess the impact of surface water runoff. This is a Phase I activity, insofar as the runoff channels within the unit boundary are concerned. Additional sampling will be required in the conveyances to McKay ditch, and within McKay ditch upstream of other units. Because surface water conveyances from other waste management units at the Rocky Flats Plant have entered both McKay Ditch and North Walnut Creek, the impact of runoff from OU11 can only be assessed by sampling these drainages upstream of the entrance point of other potentially contaminated water flows.

2.4 SITE CONCEPTUAL MODEL

The site conceptual model is employed to identify known and suspected sources of contamination, types of contamination, impacted media, contaminant migration pathways, and human and environmental receptors. The primary purpose of developing a conceptual model for the West Spray Field is to identify exposure pathways by which human populations and ecological biota may be exposed to contaminants. The site conceptual model is tied directly to the development of the RFI/RI data quality objectives, and subsequently to the development of the field sampling plan which specifies site sampling activities. The goal of linking the conceptual model to the field sampling plan is to focus the RFI/RI field activities on the collection of data that is relevant to the evaluation of human health and ecological risks.

Per U.S. EPA "Risk Assessment Guidance for Superfund, 1989," an exposure pathway is considered complete if it includes the following five components: a contaminant source, release mechanism, transport medium, exposure route, and receptor (refer to Figure 2-9). Based on preliminary analysis, the conceptual model elements that are specific to the West Spray Field - OU 11 are depicted in Figure 2-10.

The conceptual model provides an overview of all potential exposure pathways that may result from releases and their relative potential for occurrence. Some exposure pathways have a higher potential for occurrence than others. In addition to identifying exposure pathways, the fate and mobility of the contaminants for each potential source and each relevant transport medium are evaluated as part of the conceptual model. The individual components of the WSF conceptual model are discussed in the subsections that follow. The Baseline Risk Assessment Plan (BRAP) and Environmental Evaluation Work Plan (EEWP) are discussed separately in Sections 8.0 and 9.0, respectively.

2.4.1 Sources of Contamination

The sources of contamination at a site are typically the transport media which are known to have been or are suspected to have been directly affected by releases. Based on this assumption and on the nature of West Spray Field contamination, as discussed in Section 2.3, OU11 contaminant sources stem primarily from the historical spray-application of excess liquids from the Solar Evaporation Ponds (207-B North and 207-B Center). Application of the liquids is known to have occurred at three separate subareas within the West Spray Field from 1982 to 1985. During this period, the sprayed wastewater may have directly impacted environmental media, particularly surface and shallow soils in the spray-application areas, and sediments in nearby drainages and streams, which are now acting as on-going sources of contamination.

While the impact of the wastewater to surface and shallow soils in the three spray-application areas and sediment in drainages are the primary sources of OU 11 contamination, potential secondary sources include subsurface soils, transported dust, surface water, groundwater, and biota. These potential sources are categorized as secondary due to the fact that they extend either from the historically applied wastewater or from on-going releases from surface and shallow soils.

2.4.2 Types of Contamination

As discussed in Section 2.3, limited screening of the types of contaminants present at the West Spray Field has been conducted. Surface and shallow soils (to an approximate depth of five feet) in the West Spray Field have been found to exhibit concentrations of radionuclides and nonradioactive contaminants above estimated background levels. Contaminants include nitrates, heavy metals, and plutonium. Volatile organic compounds have also been identified at trace concentrations in soils, however, their presence has not been validated.

Recent monitoring of alluvial wells within the present West Spray Field - OU 11 boundaries has also identified plutonium, americium, nitrates, heavy metals, and volatile organic compounds above estimated background concentrations in groundwater (EG&G, 1991c). Additional constituents in groundwater that have exceeded background estimates include magnesium, sodium, and uranium-233,234. Data relative to surface water, sediment, and air quality in the West Spray Field area have not been collected to date.

2.4.3 Release Mechanisms

Following the identification of contaminant sources and types, release mechanisms are evaluated. Release mechanisms are physical and/or chemical processes by which contaminants are released from the identified sources. This includes mechanisms which release contaminants directly from the source and those which release contaminants from impacted transport media. An evaluation of release mechanisms associated with the historically applied wastewater, the potentially contaminated surface soils and sediment, and the other minor contaminant sources are discussed in the following paragraphs.

2.4.3.1 Historical Release Mechanisms

Due to the large volume of water that was applied to the West Spray Field over a relatively short period of time, it is possible that a portion of the water infiltrated into the vadose zone, resulting in impacted subsurface soils. Following percolation through the vadose zone, contaminant-bearing water may have extended vertically into alluvial groundwater. Impacted groundwater could then result in contaminated surface seeps or springs, or potentially intersect wells. Seeps have been documented to occur at a number of locations across the Rocky Flats Plant site (Hydro-Search, Inc., 1985).

Depending upon application rates during spraying activities, significant surface run-off of the wastewater and sediment loading in drainages within the West Spray Field area may have occurred. This is supported by the discussion within Section 2.3. Distinct drainage patterns within the West Spray Field boundaries, identified via vegetative changes as seen in the aerial photographs, support the conclusion that significant run-off occurred. This is additionally supported by the construction of the collection ditch system along the north and east portions of the WSF during 1984.

As discussed in the Physical Setting Section 1.3.3, run-off of the wastewater could have also impacted drainages north of the West Spray Field area, including McKay Ditch (which eventually turns into North Walnut Creek further to the east) and Upper Church Ditch. This is supported by the discussion in Section 2.3.4.1 describing a well-documented surface water flow event which impacted McKay Ditch. A less probable occurrence, although, still a valid potential pathway is the flow of wastewater run-off into Woman Creek to the south of the West Spray Field. In addition, directly southeast of the WSF is a raw water storage pond. The pond is surrounded by approximately six foot high, asphalt-lined berms which would prevent potential surface run-off impacts from the WSF.

Although surface water can no longer be impacted via wastewater run-off, it is possible that sediment loading occurred, and that contaminants were precipitated or deposited. Such contaminants may then be remobilized through precipitation events and ephemeral flow within the ditches and creeks.

During the spray application of wastewater at the West Spray Field, it is also possible that direct release of contaminants occurred through volatilization. Release via this mechanism was historic and is no longer on-going. In addition, volatile contaminants comprised only a minor portion of the overall quality of the spray-applied wastewater as discussed in Section 2.3.

Sprayed wastewater also potentially impacted flora and fauna on and adjacent to the West Spray Field area. Potential impacts to ecological receptors are discussed in Section 9.0.

2.4.3.2 On-Going Release Mechanisms

Since spray-application of wastewater ceased in approximately 1985, the most significant potential sources of on-going contamination at the West Spray Field are impacted surface and shallow soils and impacted sediments. In general, contaminated soils and sediments at the West Spray Field may be impacting the same environmental media via the mechanisms described under Historical Release Mechanisms, Section 2.4.3.1. Two release mechanisms of contaminants from impacted surface soils and sediments, that are not described under historical mechanisms, are the generation of fugitive dust and tracking. The transport of contaminants via dust not only creates a direct pathway to receptors, it also generates a number of secondary release routes as the impacted dust settles on other environmental media. Tracking of contaminated soils or sediment can occur through the use of vehicles and through humans and fauna crossing the West Spray Field. Because the West Spray Field is no longer in use, the current potential for contaminant transport through tracking is expected to be negligible.

Surface water contained within the pond directly southeast of West Spray Field could be affected via air transport of impacted dust (refer to Figure 2-1 for pond location). The pond is used for raw water storage for the Rocky Flats Plant. The pond has the capacity to store 1.75 million gallons and is the primary potable water supply at the plant.

2.4.3.3 Contaminant Behavior

The chemical and mechanical characteristics of the individual contaminants affect their mobility in the various environmental media. As discussed in Section 2.4.2, contaminants at the West Spray Field include radionuclides, heavy metals, other inorganics such as nitrates, and trace volatile organic compounds. The characteristics of some of these contaminants are discussed briefly in the following paragraphs in order to aid in understanding their affinity for different environmental media and their migration and transport behavior.

The mobility of heavy metals is generally limited by adsorption to clays, organic matter and iron oxyhydroxides present in soils. The solubility of metals can also be inhibited by the formation of oxide or hydroxide solids under sulfate conditions. As a result, the migration of heavy metals is typically limited to the shallow soil environment due to attenuating factors such as adsorption and insolubility. Therefore, transport in association with suspended particulates or bed load solids in surface water or as dust in air is a more common means of heavy metal transport.

Nitrate, which occurs naturally as a minor constituent in ground and surface waters, was a major component in the solar pond wastewater. Nitrate can ionically combine with trace metals in solution and therefore, limit the solubility of metals and other major cations through the formation of solid precipitates.

Radionuclides, including plutonium and americium, form insoluble hydroxide and oxide solids under neutral to basic conditions, which limits their mobility in subsurface soils. Plutonium and americium may be transported in association with particulates in surface water or air, or possibly as colloids in groundwater. In addition, the presence of high concentrations of complexing anions may act to increase their solubility.

In summary, contaminant transport is not only dependent upon the environmental media by which contaminants travel, but also on the nature of the compounds themselves. In general, factors that affect contaminant behavior in environmental media include ionic exchange, diffusivity and dispersion, solubility, adsorption, oxidation-reduction, and pH conditions.

2.4.4 Migration Pathways (Transport Media)

Transport media are the environmental media into which contaminants are released from the source and from which the contaminants are in turn released to a receptor. The primary potential pathways for contaminant migration are air, surface water, groundwater, and flora and fauna. More specifically, air provides a route for the release of fugitive dust which can in turn disperse and impact additional surface soils, vegetation, and surface water in the raw water pond to the southeast of the West Spray Field. Surface water is a relevant migration pathway as it relates to sediment loading and subsequent release during flow periods of the ditches and creeks and surface run-off due to precipitation events. Potential pathways pertaining to flora and fauna and addressed in Section 9.0.

The primary migration pathways for groundwater are either seepage, where groundwater flow intersects the ground surface, or by water supply wells tapping the affected groundwater.

2.4.5 Receptors and Exposure Routes

Exposure routes are avenues through which contaminants are physiologically incorporated by a receptor. Receptors are the populations exposed to contaminants at potential points of contact with a contaminated medium. Human receptors may be exposed to windblown contaminated soil, external radiation, contaminated groundwater, or surface water. The three potential exposure routes to a receptor include: ingestion, inhalation, and dermal contact. Biota as receptors are addressed in Section 8.0.

2.4.6 The Conceptual Model in the RFI/RI Process

As previously stated, the elements of the site conceptual model for Operable Unit 11 are outlined in Figure 2-10, which depicts sources of contamination, mechanisms of contaminant release, potential contaminant migration pathways, and receptors. The model as pictured is based on an initial evaluation of the preliminary data available. As additional information is obtained, the overall model and its specific components may be refined or expanded to address the issues of concern.

TABLE 2-1

APPLICATION OF LIQUID FROM POND 207-B NORTH TO THE WEST SPRAY FIELD

DATE	VOLUME APPLIED (gallons)
4/82	522,000
6/82	760,000
10/82	244,000
Yearly Subtotal	1,526,000
1/83	555,000
6/83	865,000
7/83	1,112,000
11/83	367,000
Yearly Subtotal	2,899,000
3/84	231,000
4/84	864,000
5/84	216,000
7/84	169,000
10/84	929,000
Yearly Subtotal	2,409,000
3/85	132,000
7/85	1,266,000
10/85	781,000
Yearly Subtotal	2,179,000
TOTAL	9,013,000

TABLE 2-2

APPLICATION OF LIQUID FROM POND 207-B CENTER TO THE WEST SPRAY FIELD

DATE	VOLUME APPLIED (gallons)
4/82	2,971,000
5/82	4,869,000
6/82	3,307,000
7/82	3,179,000
8/82	2,130,000
9/82	2,334,000
10/82	3,371,000
11/82	3,018,000
12/82	434,000
Yearly Subtotal	25,613,000
1/83	556,000
2/83	1,193,000
3/83	760,000
5/83	820,000
6/83	1,135,000
7/83	2,140,000
8/83	1,426,000
9/83	1,277,000
10/83	1,859,000
11/83	1,691,000
12/83	2,493,000
Yearly Subtotal	15,350,000
2/84	2,209,000
3/84	710,000
4/84	597,000
5/84	2,315,000
6/84	1,901,000
7/84	1,488,000
10/84	660,000
12/84	1,825,000
Yearly Subtotal	11,705,000

TABLE 2-2 (continued)

APPLICATION OF LIQUID FROM POND 207-B CENTER TO THE WEST SPRAY FIELD

DATE	VOLUME APPLIED (gallons)
1/85	2,087,000
2/85	250,000
3/85	455,000
4/85	1,265,000
5/85	110,000
6/85	528,000
Yearly Subtotal	4,695,000
TOTAL	57,363,000

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

.YTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
		(1) 7.5 - 9.6 (7) 8.0 - 8.5	(1) 7.3 - 11.3 (7) 9.6 - 10.5	(11) 7.8 - 8.0 (13) 7.7 (15) 6.99 - 7.23	(8) 3.5 - 10 (9) 9.8
ate as Nitrogen	(mg/l)	(1) 335 - 1,367 (7) 212 - 507	(1) ND - 15.6 (7) 346.4 - 1221	(13) 460 (14) 400 (15) 341 - 724	(8) 0.2 - 16.6 (9) <0.2
l Disolved Solids	(mg/l)	.....	.....	(14) 2,784 - 2,868 (15) 2,360 - 4,555	(8) 340 - 630
ide	(mg/l)	.....	.....	(11) <0.05 (13) <0.01	(10) 0.016
ONUCLIDES (Units in pCi/l)					
s Alpha	(pCi/l)	(1) 13(50) - 323(33) (3) 74(58) - 120(50) (7) 52(20) - 200(80)	(1) 4(0) - 59(23) (7) 57(21) - 2,500(400)	(11) 100(40) - 120(40) (13) 64(16) (14) 71(4) - 84(22) (15) 10.8(13.3) - 50.1(22.0)	(8) 0 - 35 (9) 34(4)
. Beta	(pCi/l)	(1) 5(25) - 163(25) (3) 56(32) - 100(92) (7) 67(3) - 200(80)	(1) 8(11) - 73(0) (7) 72(16) - 1,500(200)	(11) 75(25) - 120(40) (13) 59(5) (14) 90(49) - 115(5) (15) 47.4(14.2) - 135(22.7)	(8) 0 - 212 (9) 65(27)
lutonium 239	(pCi/l)	(3) ND	.....	(11) 0.05(0.08) - 0.16(0.10) (14) 0.0(0.55) - 0.0(1.3) (15) 0.0(0.37) - 0.84(0.44)	.....
mericum 241	(pCi/l)	(3) ND	.....	(11) -0.01(.03) - 0.02(0.05) (14) 0.0(2.3) - 0.0(8.5)	.....

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ALYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Uranium	(pCi/l)	.....	.....	.....	.....
Uranium 233 + 234	(pCi/l)	(3) 50(2) - 53(2)	.....	(11) 62(2) - 66(2) (15) 27.6(4.92) - 122(4.16)	.....
Uranium 234	(pCi/l)	.....	.....	(13) 14.8(1.2) (14) 50(7) - 58(7)	.....
Uranium 235	(pCi/l)	.....	.....	(13) 3.6(0.6) (14) 1.2(0.8) - 1.4(1.0)	.....
Uranium 238	(pCi/l)	(3) 31(1) - 33(1)	.....	(11) 40(2) - 44(2) (13) 9.9(1.0) (14) 31(5) - 36(5) (15) 15.2(3.68) - 84.8(3.47)	.....
tium	(pCi/l)	(3) 1,200(300) - 1,300(300)	.....	(11) 2700(300) - 3400(300) (13) 1,931(64) (14) 1,600(110) - 2,200(110) (15) 2,480(304) - 2,960(308)	.....
al Radium	(pCi/l)	.....	.....	(13) <2	(8) <0.1 (9) <0.1
ALS (Units in ppm)					
Aluminum	(mg/l)	(2) 0.16 (2) 1 (4) ND (5) <.0028 (6) <.003	(2) 0.15 (2) 2.0 (5) <.0032 (6) <.0035	(11) <0.2 (13) 0.087 (14) <0.029 (15) <0.2	(8) 0.32 (9) 0.32
Antimony	(mg/l)	(5) <.028 (6) <.03	(5) <.032 (6) <.035	(11) <0.06 (13) <0.06 (14) <0.06 (15) <0.060	(8) <0.05 (9) <0.05 (10) <0.005

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

YTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Arsenic	(mg/l)	(4) ND (5) <.01 (6) <.01	(5) <.01 (6) <.01	(11) <0.01 (13) <0.01 (14) <0.01 (15) <0.01	(10) <0.005
Barium	(mg/l)	(4) ND - 0.220 (5) <1.0 (6) <1.0	(5) <1.0 (6) <1.0	(11) <0.2 (13) 0.171 (14) 0.1832 - 0.1878 (15) <0.2	(8) <0.5 (9) <0.5
Beryllium	(mg/l)	(4) ND (5) <.05 (6) 0.06	(5) <.05 (6) <.05	(11) <0.005 (13) <0.004 (15) <0.005	(10) <0.005
Bismuth	(mg/l)	(5) <.014 (6) <.015	(5) <.016 (6) <.018	.....	.....
Boron	(mg/l)	(2) 0.29 (2) 0.31 (5) 0.14 (6) 0.09	(2) 0.24 (2) 0.67 (5) 0.13 (6) 0.071	.....	(8) <0.67 (9) 0.67
adnium	(mg/l)	(4) ND (5) <.01 (6) 0.01	(5) <.01 (6) 0.01	(11) <0.005 (13) 0.0007 (14) <0.005 (15) <0.005	(10) <0.005
alicum	(mg/l)	(2) 20.0 (2) 290 (4) 176 - 198 (5) 96.0 (6) 180.0	(2) 2.9 (2) 45.0 (5) 95.0 (6) 66.0	(11) 308 - 319 (13) 242 - 255 (14) 247 - 250 (15) 240 - 400	(8) 0.1 - 0.6
erium	(mg/l)	(5) <2.8 (6) <3.0	(5) <3.2 (6) <3.5	.....	.....
esium	(mg/l)	(2) ND (2) ND (5) <.28 (6) <.3	(2) ND (2) 0.041 (5) <.32 (6) 0.35	(14) <0.2	.....

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

LYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Cobalt	(mg/l)	(4) ND (5) <.014 (6) <.015	(5) <.016 (6) <.018	(11) <0.02 (13) <0.02 (14) <0.022 (15) <0.05	(8) <0.01 (9) <0.01
Chromuim	(mg/l)	(4) ND (5) <.05 (6) <.05	(5) <.05 (6) <.05	(11) 0.007 - 0.009 (13) <0.01 (14) <0.01 (15) <0.01	(8) 0.05 (10) 0.025
Copper	(mg/l)	(2) ND (2) ND (4) ND (5) <.014 (6) <.015	(2) 0.016 (2) 0.037 (5) <.016 (6) <.018	(11) <0.005 (13) <0.008 (14) <0.0063 (15) <0.025	(8) <0.1 (10) <0.005
Germanium	(mg/l)	(5) <.014 (6) <.015	(5) <.016 (6) <.018	.....	.....
Iron	(mg/l)	(2) 0.28 (2) 0.29 (4) ND (5) 0.057 (6) <.03	(2) 0.074 (2) 0.2 (5) 0.13 (6) <.035	(11) <0.02 (13) 0.101 (14) <0.0069 (15) <0.1	(8) 0.52 (9) 0.52
Lead	(mg/l)	(2) ND (2) 0.0035 (4) ND (5) <.0028 (6) <.003	(2) ND (2) 0.002 (5) <.0032 (6) <.0035	(11) <0.005 (13) <0.005 (14) <0.005 (15) <0.005	(10) <0.005
.ithium	(mg/l)	(2) 0.37 (2) 3.5 (5) 1.7 (6) 6.0	(2) 0.052 (2) 0.41 (5) 2.9 (6) 3.5	.....	.....
langanese	(mg/l)	(2) ND (2) ND (4) ND - 0.015 (5) <.0028 (6) <.003	(2) 0.022 (2) 0.081 (5) <.0032 (6) <.0035	(11) 0.012 - 0.013 (13) 0.006 (14) 0.0057 - 0.0074 (15) <0.015	(8) <0.1 (9) 0.04

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

YTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Magnesium	(mg/l)	(2) 87.0 (2) 120.0 (4) 66.4 - 72.6 (5) 88.0 (6) 80.0	(2) 3.9 (2) 13.0 (5) 86.0 (6) 91.0	(11) 76.8 - 77.4 (13) 64.2 - 66.6 (14) 64.2 - 65.9 (15) 65 - 97	(8) 5.0 (9) 5.0
Mercury	(mg/l)	(4) ND (5) <.002 (6) <.002	(5) <.002 (6) <.002	(11) 0.0004 - 0.0005 (13) <0.0002 (14) <0.0002 (15) <0.0002	(10) <0.0001
Molybdenum	(mg/l)	(2) ND (2) 0.0069 (5) <.0028 (6) 0.003	(2) 0.016 (2) 0.037 (5) 0.019 (6) 0.035	(14) <0.022	(8) <0.05 (9) <0.05
Nickel	(mg/l)	(2) ND (2) ND (4) ND - 0.050 (5) <.028 (6) <.03	(2) 0.015 (2) 0.016 (5) <.032 (6) <.035	(11) <0.02 (13) <0.024 (14) <0.037 (15) <0.040	(10) <0.02
Niobium	(mg/l)	(5) <.14 (6) <.15	(5) <.16 (6) <.18	.....	.....
Phosphorous	(mg/l)	(2) ND (2) ND (5) <.14 (6) <.15	(2) 0.074 (2) 0.2 (5) <.16 (6) 0.18	.....	(8) 0.8 (9) 0.80
Potassium	(mg/l)	(2) 82.0 (2) 120 (4) 56.1 - 62.7 (5) 89.0 (6) 64.0	(2) 30.0 (2) 36.0 (5) 98.0 (6) 110.0	(11) 71.5 - 73.7 (13) 64.9 - 66.9 (14) 64 - 65 (15) 38 - 101	(8) 2 - 42
Rubidium	(mg/l)	(5) <.28 (6) <.3	(5) <.32 (6) <.35	.....	.....

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

YTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Selinium	(mg/l)	(2) 0.01 (2) 0.02 (4) 0.009 (5) <.01 (6) 0.024	(2) ND (2) ND (5) <.01 (6) 0.019	(11) 0.011 - 0.012 (13) 0.0051 (14) <0.005 (15) <0.005 - 0.009	(10) <0.005
Silicon	(mg/l)	(2) 2.1 (2) 5.6 (5) 2.1 (6) <.5	(2) 2.4 (2) 5.5 (5) 1.4 (6) 1.6	.....	(8) 5 - 10
ilver	(mg/l)	(2) ND (2) 0.082 (4) ND (5) <.0028 (6) <.003	(2) 0.0016 (2) 0.015 (5) <.0032 (6) <.0035	(11) 0.010 - 0.012 (13) 0.008 (14) <0.0076 (15) 0.010 - 0.060	(10) <0.005
odium	(mg/l)	(2) 370.0 (2) 620.0 (4) 363 - 451 (5) 820. (6) 770.0	(2) 67.0 (2) 250.0 (7) 800.0 (5) 650.0 (6)	(11) 451 - 462 (13) 397 - 406 (14) 378 - 383 (15) 300 - 520	(8) 104 - 200
trontium	(mg/l)	(2) 1.2 (2) 3.5 (5) 0.14 (6) 0.21	(2) 0.28 (2) 0.52 (5) 0.16 (6) 0.14	(14) 1.99 - 2.04 (15) 2.2 - 3.6	.....
antalum	(mg/l)	(5) <.028 (6) <.03	(5) <.032 (6) <.035	.....	.....
ellurium	(mg/l)	(5) <.28 (6) <.3	(5) <.32 (6) <.35	.....	.....
hallium	(mg/l)	(5) <.014 (6) <.015	(5) <.016 (6) <.018	(11) <0.01 (13) <0.01 (14) <0.01 (15) <0.01	(10) <0.005
horium	(mg/l)	(5) <.028 (6) <.03	(5) <.032 (6) <.035	.....	.....

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

LYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Tin	(mg/l)	(4) ND (5) <.028 (6) <.03	(5) <.032 (6) <.035	(11) <0.4 (13) <0.038	.....
Titanium	(mg/l)	(5) <.014 (6) <.015	(5) <.016 (6) <.018	.....	(8) <0.1 (9) <0.1
Tungsten	(mg/l)	(5) <1.4 (6) <1.5	(5) <1.6 (6) <1.8	.....	.....
Uranium	(mg/l)	(5) <1.4 (6) <1.5	(5) <1.6 (6) <1.8	.....	.....
Vanadium	(mg/l)	(2) ND (2) ND (4) ND (5) <.028 (6) <.03	(2) ND (2) 0.0081 (5) <.032 (6) <.035	(11) <0.05 (13) 0.015 (14) <0.024 (15) <0.050	.....
Zinc	(mg/l)	(2) ND (2) ND (4) ND - 0.022 (5) <.14 (6) <.15	(2) 0.041 (2) ND (5) <.16 (6) <.18	(11) 0.024 - 0.030 (13) 0.032 (14) 0.05 - 0.08 (15) 0.03 - 0.04	(8) 0.1 - 0.3 (10) 0.042
Zirconium	(mg/l)	(2) ND (2) ND (5) <.028 (6) <.03	(2) 0.0041 (2) ND (5) <.032 (6) <.035	.....	.....
ols	(mg/l)	(4) 0.003 - 0.046	.....	(11) 0.01	(10) 0.004

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

YTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
ILES (Units in ppb)					
romethane	(ug/l)	(11) <10	.....	(11) <10 (12) <1 (15) <10	(10) <10
omethane	(ug/l)	(11) <10	.....	(11) <10 (12) <1 (15) <10	(10) <10
l chloride	(ug/l)	(11) <10	.....	(11) <10 (12) <1 (15) <10	(10) <10
oethane	(ug/l)	(11) <10	.....	(11) <10 (12) <1 (15) <10	(10) <10
lene chloride	(ug/l)	(11) 19 - 35	.....	(11) 3 - 14 (12) <4 (15) 1.0	(10) <5
ne	(ug/l)	(11) <10	.....	(11) <10 (12) <2 (15) <10	.....
n disulfide	(ug/l)	(11) <5	.....	(11) <5 (12) <1 (15) <5	.....
lorofluoromethane	(ug/l)	.....	.....	(12) <1	(10) <5
ichloroethene	(ug/l)	(11) <5	.....	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ALYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
l-Dichloroethane	(ug/l)	(11) <5	.....	(11) <5 (12) <1 (15) <5	(10) <5
al 1,2-Dichloroethene	(ug/l)	(11) <5	.....	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
oroform	(ug/l)	(11) 3 - 6	.....	(11) 3 - 6 (12) <1 - 1.4 (13) 2 (14) <4 (15) 2.0	(10) <5
-Dichloroethane	(ug/l)	(11) <5	.....	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
utanone	(ug/l)	(11) <10	.....	(11) <10 (12) <1 (15) <10	.....
,1-Trichloroethane	(ug/l)	(11) <5	.....	(11) <5 (12) <1 - 4.8 (13) 9 (14) <4 (15) <5	(10) <5
on tetrachloride	(ug/l)	(11) <5	.....	(11) 6 - 7 (12) <1 - 2.1 (13) 8 (14) 6 (15) 1.0	(10) <5
l acetate	(ug/l)	(11) <10	.....	(11) <10 (15) <10	.....

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ALYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
omodichloromethane	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
2-Dichloropropane	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
1,3-Dichloropropene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
chloroethene	(ug/l)	(11) <5	-----	(11) 7 - 8 (12) 2.4 - 3.7 (13) 6 (14) 8 (15) <5	(10) <5
zene	(ug/l)	(11) <5	-----	(11) 1 (12) <1 (15) <5	(10) <5
romochloromethane	(ug/l)	(11) <5	-----	(11) <5 (12) <2 (15) <5	(10) <5
,2-Trichloroethane	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
3-Dichloropropene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
loroethylvinyl ether	(ug/l)	(11) <10	-----	(11) <10 (12) <2 (15) <10	(10) <5

TABLE 2-3

LIQUID CHARACTERIZATION SUMMARY 1984 - 1988

"( )" - Test Result Reference Number

ANALYTE	UNITS	POND 207-B NORTH	POND 207-B CENTER	INTERCEPTOR TRENCH PUMP HOUSE	SANITARY TREATMENT PLANT EFFLUENT
Bromoform	(ug/l)	(11) <5	-----	(11) <5 (12) <4 (15) <5	(10) <5
-Methyl-2-Pentanone	(ug/l)	(11) <10	-----	(11) <10 (12) <1 (15) <10	-----
2-Hexanone	(ug/l)	(11) <10	-----	(11) <10 (15) <10	
,1,2,2-Tetrachloroethane	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
etrachloroethene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (14) <4 (15) <5	(10) <5
oluene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
hlorobenzene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
thylbenzene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	(10) <5
tyrene	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	-----
otal Xylenes	(ug/l)	(11) <5	-----	(11) <5 (12) <1 (15) <5	-----

TABLE 2-3

1. Summary of weekly sampling for Ponds 207B North and Center liquids, Appendix 3, Table 3-II.

2. Summary of two sets of metals analyses of Ponds 207B North and Center liquids, October 1984 and April 1985, Appendix 3, Table 3-III.

3. Summary of radiochemical analyses, April and May 1986, Appendix 4, Table 4-I.

4. Summary of metals and phenols testing, April and May, 1986, Appendix 3, Table 3-IV.

5. 207B Solar Pond North and Center quarterly metals analysis, August 14, 1987, Lab No. E87-3918, Appendix 4.

6. 207B Solar Pond North and Center quarterly metals analysis, November 30, 1987, Lab No. E87-4254, Appendix 4.

7. 207B Solar Pond weekly analysis results (liquids), October 1987 to June 1988.

8. Table 3-9, typical sewage effluent quality, Building 995 outfall, Rocky Flats Plant, from Draft of ASI Report on Water Management at RFP, August, 1988.

9. Analytical report from General Laboratory, 374 product water and 995 outfall, received 5-14-87, from draft of ASI report on Water Management at RFP, August, 1988.

10. Report of analysis from Accu-Labs Research, Inc., 374 product water and 995 effluent, 6-18-87, from draft of ASI report on Water Management at RFP, August, 1988.

11. Laboratory test results, Solar Ponds 207A and 207B North, Interceptor Trench Pump House, Buffer Zone, April and May, 1986; Appendix 4 of Solar Evaporation Ponds Closure Plan, July 1, 1988.

12. Resample of Interceptor Trench Pumphouse, Laboratory Test Results, Solar POnds 207A and 207B North, Interceptor Trench Pump House, Buffer Zone, April and

May, 1986; Appendix 4 of Solar Evaporation Ponds Closure Plan, July 1, 1988.

13. NEIC Ground-Water Monitoring Evaluation, U.S. Department of Energy, Rocky Flats Plant, July, 1988, EPA-330/2-88-051.

14. 1987 Interceptor Trench Pumphouse Water Data, Rocky Flats Plant, Golden, Colorado.

15. 1988 Surface Water Sampling Data, Roy F. Weston, Inc., Stockton Analytical Laboratory, September 1, 1988, I.D. SW88A084 and SW88A086.

TABLE 2-4

1986 SOIL SAMPLING PARAMETERS
WEST SPRAY FIELD AND BUFFER ZONE

<u>Organics</u>

Target Compound List-Volatiles
Target Compound List-Semi-Volatiles

<u>Metals</u>

Target Analyte List-Metals

<u>Radionuclides</u>

Gross Alpha
Gross Beta
Plutonium-239
Americium-241
Uranium-233,-234
Uranium-238
Tritium

<u>Other</u>

RCRA Characteristics - Reactivity, Corrosivity (pH)
Ignitability
Total Cyanide
Hexavalent Chromium
Sulfide

TABLE 2-5

1988 SOIL SAMPLING PARAMETERS FOR TEST PITS WEST SPRAY FIELD

<u>Organics</u>

Target Compound List - Volatiles Organics
Total Organic Carbon

<u>Radionuclides</u>

Gross Alpha
Gross Beta
Plutonium-239
Uranium-233
Uranium-234
Uranium-238

<u>Other</u>

Nitrates
Lead
Mercury
% Solids
Volatile Solids

TABLE 2-6

1989 BACKGROUND ALLUVIUM ANALYSIS RESULTS

Metals	Mean Concentration (mg/kg)	Upper Tolerance Interval
Aluminum	11,909	13,420
Antimony	13.3	--
Arsenic	3.9	4.3
Barium	73.3	79.5
Beryllium	4.0	4.7
Calcium	4,378	--
Cadmium	1.21	--
Chromium (Total)	16.9	--
Cobalt	12.0	--
Iron	12,630	13,750
Lead	8.0	--
Magnesium	2,268	2,484
Maganese	193	235
Mercury	0.15	--
Nickel	20.1	--
Potassium	1,495	1,558
Selenium	2.6	--
Silver	5.1	--
Sodium	1,133	--
Thallium	2.3	--
Tin	51.4	--
Vanadium	28.6	--
Zinc	24.2	--

Radionuclides	Mean Concentration (pCi/g)	Upper Tolerance Interval
Gross Alpha	21.5	38.4
Gross Beta	23.5	36.8
Plutonium-239	0.002	0.015
Americium-241	-0.0015	0.0135
Uranium-233+234	0.59	0.66
Uranium-238	0.62	0.68
Tritium	0.18	0.41

NOTES:

(1) Background values based on up to 77 samples collected from Rocky Flats Alluvium.

(2) "-" Indicates tolerance interval not calculated.

(3) Tritium is in units of pCi/l of soil water.

BLE 2-7

METALS (1986 SOILS DATA)

METALS (mg/kg)		Al	Cr	Fe	Pb	Mn	Zn	V	As	Co	Ca	Cu	Mg	Ni	K	Na
<u>WEST SPRAY FIELD</u>																
Surface Scrape	1D3	8330	11	10800	61	295	50*	-	9.2	[13]	[2060]	[11]	[1390]	20	[1840]	-
	2D3	7570	10	10400	63	337	52*	-	8.3	-	[2240]	[11]	[1340]	-	[1750]	-
	3D3	7670	9.6	9160	42	314	38	-	8.9	-	[1800]	[10]	[1230]	-	[1650]	[75]
0-6"	1E3	7390	8.6	9240	32	289	28	-	6.7	-	[1260]	[6.3]	[1090]	-	[1330]	-
	2E3	8760	9.4	12500	29	326	36	-	-	-	[1310]	[11]	[1240]	-	[1590]	-
	3E3	8420	12	9980	18	277	24	-	-	-	[1170]	[6.9]	[1040]	[19]	[1310]	-
6-12"	1F3	7010	11	11300	15	240	26	-	6.1	-	[1070]	[7.3]	[922]	-	[1200]	-
	2F3	8920	6.8	9960	23	235	29	-	-	-	[1280]	[9.2]	[1150]	-	[1490]	[68]
	3F3	10600*	14*	10100	14	206	27	-	-	-	[1500]	[8.2]	[1310]	-	[1660]	-
<u>BUFFER ZONE</u>																
Surface Scrape	1A3	8770	10	11000	38	272	41	-	-	-	[1840]	[9.6]	[1360]	-	[1700]	-
	2A3	9140	10	11400	48	337	49	-	6.8	-	[1930]	[9.7]	[1490]	[13]	[1860]	[217]
	3A3	9050	13	12300	42	286	44	-	-	-						
0-6"	1B3	8190	11	9080	31	274	33	-	-	-	[1660]	[6.9]	[1240]	[13]	[1390]	-
	2B3	6540	9	9610	29	247	29	-	7	[12]	[1320]	[8.4]	[997]	-	[1260]	-
	3B3	6740	5.7	9580	17	215	25	6.4	[1400]	-	[8.3]	[976]	[13]	[1190]	[68]	
6-12"	1C3	8640	10	12400	19	293	23	38	-	[22]	[1100]	[6.6]	[1030]	[16]	[1100]	-
	2C3	7640	9.6	10200	16	196	30	-	-	-	[1400]	[9.1]	[1060]	[17]	[1250]	-
	3C3	7200	5.6	10900	15	285	20	-	-	25	[1020]	[9.9]	[883]	-	[951]	-

NOTE: "-" Indicates reported value below detection limit.

Al = Aluminum Co = Cobalt Fe = Iron Mn = Manganese Pb = Lead

As = Arsenic Cr = Chromium K = Potassium Na = Sodium V = Vanadium

Ca = Calcium Cu = Copper Mg = Magnesium Ni = Nickel Zn = Zinc

Brackets indicate value estimated below the detection limit

TABLE

METALS RESULTS FROM TEST PITS 1988 SOILS DATA

Test Pit Number	Field Sample Number	Date Sampled	Depth Increment (ft)	Units	Mercury (Hg), total	Lead (Pb), total
WEST SPRAY FIELD TEST PITS						
WSF01	WSF0101	05/03/88	1.00 - 1.00	mg/kg	0.10 U	9.1
WSF01	WSF0102	05/03/88	2.50 - 2.50	mg/kg	0.46	13
WSF01	WSF0104	05/03/88	4.50 - 4.50	mg/kg	0.10 U	9.4
WSF02	WSF0201	05/03/88	0.90 - 0.90	mg/kg	0.18 J	9.7
WSF02	WSF0202	05/03/88	2.20 - 2.20	mg/kg	0.13 J	9.4
WSF02	WSF0204	05/03/88	4.40 - 4.40	mg/kg	0.17 J	15
WSF03	WSF0301	05/03/88	0.90 - 0.90	mg/kg	0.10 U	14
WSF03	WSF0302	05/03/88	2.20 - 2.20	mg/kg	0.24	13
WSF03	WSF0305	05/03/88	4.70 - 4.70	mg/kg	0.15 J	14
WSF04	WSF0401	05/03/88	0.90 - 0.90	mg/kg	0.10 U	11
WSF04	WSF0402	05/03/88	2.50 - 2.50	mg/kg	0.10 U	10
WSF04	WSF0404	05/03/88	4.10 - 4.10	mg/kg	0.12 J	13
WSF05	WSF0501	05/03/88	0.75 - 0.75	mg/kg	0.10 U	17
WSF05	WSF0502	05/03/88	2.00 - 2.00	mg/kg	0.12 J	24
WSF05	WSF0504	05/03/88	4.20 - 4.20	mg/kg	0.10 U	15
WSF06	WSF0601	05/04/88	0.70 - 0.70	mg/kg	0.10 U	13
WSF06	WSF0602	05/04/88	2.10 - 2.10	mg/kg	0.21	13
WSF06	WSF0604	05/04/88	4.60 - 4.60	mg/kg	0.34	17
WSF07	WSF0701	05/04/88	0.50 - 0.50	mg/kg	0.10 U	20
WSF07	WSF0702	05/04/88	2.00 - 2.00	mg/kg	0.17 J	10
WSF07	WSF0704	05/04/88	3.80 - 3.80	mg/kg	0.14 J	12
WSF08	WSF0801	05/04/88	0.65 - 0.65	mg/kg	0.10 U	26
WSF08	WSF0802	05/04/88	2.00 - 2.00	mg/kg	NR	11
WSF08	WSF0805	05/04/88	4.60 - 4.60	mg/kg	0.15 J	9.3
WSF09	WSF0901	05/04/88	0.50 - 0.50	mg/kg	0.10 U	14
WSF09	WSF0902	05/04/88	2.00 - 2.00	mg/kg	0.20	17
WSF09	WSF0904	05/04/88	4.40 - 4.40	mg/kg	0.10 U	8.5
WSF10	WSF1001	05/05/88	0.50 - 0.50	mg/kg	0.10 U	19
WSF10	WSF1002	05/05/88	1.70 - 1.70	mg/kg	NR	15
WSF10	WSF1004	05/05/88	3.50 - 3.50	mg/kg	0.34	15
WSF11	WSF1101	05/05/88	0.50 - 0.50	mg/kg	0.10 U	20
WSF11	WSF1102	05/05/88	2.00 - 2.00	mg/kg	0.23	11
WSF11	WSF1105	05/05/88	4.50 - 4.50	mg/kg	0.10 U	10
WSF12	WSF1201	05/05/88	0.50 - 0.50	mg/kg	0.10 U	21
WSF12	WSF1202	05/05/88	2.00 - 2.00	mg/kg	0.100	8.3
WSF12	WSF1205	05/05/88	4.00 - 4.00	mg/kg	0.10 U	7.3

Notes: NR - Analyte not requested U - Analyzed but not detected J - Present below detection limit B - Present in laboratory blank

TABLE 2-9
RADIONUCLIDE RESULTS (1986 SOILS DATA)

	Sample Number	Gross Alpha (pCi/g)	Gross Beta (pC)i/g)	Pu^{239} (pCi/g)	Am^{241} (pCi/g)	$U^{233,234}$ (pCi/g)	U^{238} (pCi/g)	H^3 (pCi/ml)
WEST SPRAY FIELD								
Surface Scrape	3D5	40(14)	34(6)	0.04(0.2)	0.02(0.06)	1.2 (0.2)	0.9 (0.2)	0.39(0.23)
	2D5	55(16)	37(6)	0.15(0.21)	0.01(0.06)	1.0 (0.2)	1.1 (0.2)	0.11(0.23)
	1D5	52(16)	40(6)	0.12(0.21)	0.01(0.05)	1.1 (0.2)	1.2 (0.2)	0.34(0.23)
0-6"	3E5	32(13)	29(6)	0.14(0.21)	0.04(0.06)	1.0 (0.2)	0.82(0.18)	0.11(0.23)
	2E5	43(14)	34(6)	0.03(0.19)	0.05(0.08)	0.74(0.18)	1.0 (0.2)	-0.09(0.22)
	1E5	44(15)	32(6)	0.07(0.20)	-0.02(0.03)	0.73(0.17)	0.80(0.18)	0.34(0.23)
6-12"	3F5	31(13)	29(6)	0.01(0.21)	-0.02(0.03)	0.83(0.19)	0.82(0.19)	0.21(0.23)
	2F5	20(11)	29(6)	0.04(0.20)	-0.02(0.03)	0.73(0.16)	0.84(0.20)	-0.08(0.22)
	1F5	21(11)	29(6)	-0.08(0.09)	-0.02(0.03)	0.59(0.13)	0.61(0.14)	0.54(0.24)
BUFFER ZONE								
Surface Scrape	1A5	67(17)	55(7)	0.10(0.20)	-0.02(0.03)	1.1 (0.2)	0.89(0.20)	0.09(0.23)
	2A5	71(18)	50(7)	0.02(0.10)	-0.02(0.03)	1.2 (0.2)	1.2 (0.2)	0.02(0.22)
	3A5	75(18)	56(7)	0.02(0.21)	0.02(0.05)	1.4 (0.2)	1.2 (0.2)	-0.05(0.22)
0-6"	1B5	46(15)	34(6)	0.01(0.10)	0.28(0.16)	0.77(0.17)	0.66(0.16)	-0.07(0.22)
	2B5	47(15)	40(7)	0.07(0.21)	0.02(0.06)	0.86(0.17)	0.92(0.18)	0.04(0.23)
	3B5	35(13)	30(6)	0.09(0.22)	0.0 (0.08)	0.89(0.19)	0.75(0.18)	0.20(0.23)
6-12"	1C5	18(11)	31(6)	0.05(0.21)	0.01(0.07)	0.67(0.17)	0.62(0.17)	0.13(0.23)
	2C5	36(13)	28(5)	0.03(0.21)	0.07(0.10)	0.67(0.15)	0.84(0.17)	0.08(0.23)
	3C5	37(14)	29(6)	0.05(0.21)	-0.02(0.03)	0.66(0.16)	0.76(0.18)	0.28(0.27)

67(17) - Number in parentheses represents error factor.

TABLE 2-10

RADIONUCLIDE RESULTS FROM TEST PITS (1988 SOILS DATA)

Test Pit Number	Field Sample Number	Date Sampled	Depth Increment (ft)	Gross Alpha	Gross Beta	Uranium 233, 234	Uranium 238	Plutonium 239, 240
WEST SPRAY FIELD TEST PITS								
WSF01	WSF0101	05/03/88	1.00 - 1.00	13 +/- 9 pci/g	21 +/- 12 pci/g	0.73 +/- 0.26 pci/g	0.65 +/- 0.15 pci/g	0.59 +/- 0.06 pci/g
WSF01	WSF0102	05/03/88	2.50 - 2.50	19 +/- 10 pci/g	15 +/- 11 pci/g	0.85 +/- 0.26 pci/g	0.84 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF01	WSF0104	05/03/88	4.50 - 4.50	14 +/- 9 pci/g	36 +/- 13 pci/g	0.86 +/- 0.26 pci/g	0.84 +/- 0.15 pci/g	0.03 +/- 0.06 pci/g
WSF02	WSF0201	05/03/88	0.90 - 0.90	10 +/- 8 pci/g	19 +/- 12 pci/g	0.82 +/- 0.26 pci/g	0.79 +/- 0.15 pci/g	0.01 +/- 0.06 pci/g
WSF02	WSF0202	05/03/88	2.20 - 2.20	9 +/- 8 pci/g	24 +/- 12 pci/g	0.79 +/- 0.26 pci/g	0.84 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF02	WSF0204	05/03/88	4.40 - 4.40	12 +/- 9 pci/g	27 +/- 12 pci/g	1.0 +/- 0.3 pci/g	1.0 +/- 0.2 pci/g	0.00 +/- 0.06 pci/g
WSF03	WSF0301	05/03/88	0.90 - 0.90	12 +/- 9 pci/g	19 +/- 12 pci/g	1.2 +/- 0.26 pci/g	1.2 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF03	WSF0302	05/03/88	2.20 - 2.20	3 +/- 6 pci/g	30 +/- 12 pci/g	0.91 +/- 0.26 pci/g	0.85 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF03	WSF0305	05/03/88	4.70 - 4.70	12 +/- 7 pci/g	22 +/- 12 pci/g	0.78 +/- 0.26 pci/g	0.85 +/- 0.15 pci/g	0.01 +/- 0.06 pci/g
WSF04	WSF0401	05/03/88	0.90 - 0.90	9 +/- 5 pci/g	14 +/- 11 pci/g	0.89 +/- 0.26 pci/g	0.85 +/- 0.15 pci/g	0.37 +/- 0.06 pci/g
WSF04	WSF0402	05/03/88	2.50 - 2.50	19 +/- 6 pci/g	24 +/- 12 pci/g	0.83 +/- 0.26 pci/g	0.70 +/- 0.15 pci/g	0.08 +/- 0.06 pci/g
WSF04	WSF0404	05/03/88	4.10 - 4.10	15 +/- 7 pci/g	31 +/- 12 pci/g	0.92 +/- 0.26 pci/g	0.90 +/- 0.15 pci/g	0.25 +/- 0.06 pci/g
WSF05	WSF0501	05/03/88	0.75 - 0.75	10 +/- 6 pci/g	11 +/- 11 pci/g	0.93 +/- 0.26 pci/g	0.92 +/- 0.15 pci/g	0.24 +/- 0.06 pci/g
WSF05	WSF0502	05/03/88	2.00 - 2.00	19 +/- 7 pci/g	29 +/- 12 pci/g	1.4 +/- 0.3 pci/g	1.3 +/- 0.2 pci/g	NR *
WSF05	WSF0504	05/03/88	4.20 - 4.20	39 +/- 10 pci/g	34 +/- 13 pci/g	1.2 +/- 0.3 pci/g	1.2 +/- 0.2 pci/g	0.01 +/- 0.06 pci/g
WSF06	WSF0601	05/04/88	0.70 - 0.70	16 +/- 7 pci/g	36 +/- 13 pci/g	0.83 +/- 0.26 pci/g	0.81 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF06	WSF0602	05/04/88	2.10 - 2.10	14 +/- 6 pci/g	27 +/- 12 pci/g	0.72 +/- 0.26 pci/g	0.83 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF06	WSF0604	05/04/88	4.60 - 4.60	12 +/- 5 pci/g	14 +/- 11 pci/g	0.76 +/- 0.26 pci/g	0.83 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF07	WSF0701	05/04/88	0.50 - 0.50	7 +/- 10 pci/g	36 +/- 13 pci/g	1.1 +/- 0.3 pci/g	0.97 +/- 0.15 pci/g	0.03 +/- 0.06 pci/g
WSF07	WSF0702	05/04/88	2.00 - 2.00	9 +/- 10 pci/g	28 +/- 12 pci/g	1.2 +/- 0.3 pci/g	0.94 +/- 0.15 pci/g	0.05 +/- 0.06 pci/g
WSF07	WSF0704	05/04/88	3.80 - 3.80	15 +/- 8 pci/g	20 +/- 12 pci/g	0.83 +/- 0.26 pci/g	0.73 +/- 0.15 pci/g	0.08 +/- 0.06 pci/g
WSF08	WSF0801	05/04/88	0.65 - 0.65	15 +/- 11 pci/g	38 +/- 12 pci/g	0.96 +/- 0.26 pci/g	0.97 +/- 0.15 pci/g	0.50 +/- 0.06 pci/g
WSF08	WSF0802	05/04/88	2.00 - 2.00	16 +/- 10 pci/g	29 +/- 12 pci/g	1.3 +/- 0.3 pci/g	0.94 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF08	WSF0805	05/04/88	4.60 - 4.60	21 +/- 12 pci/g	23 +/- 11 pci/g	0.92 +/- 0.26 pci/g	0.98 +/- 0.15 pci/g	0.03 +/- 0.06 pci/g
WSF09	WSF0901	05/04/88	0.50 - 0.50	12 +/- 11 pci/g	27 +/- 12 pci/g	0.83 +/- 0.26 pci/g	0.67 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF09	WSF0902	05/04/88	2.00 - 2.00	14 +/- 12 pci/g	24 +/- 13 pci/g	1.6 +/- 0.3 pci/g	1.4 +/- 0.2 pci/g	0.03 +/- 0.06 pci/g
WSF09	WSF0904	05/04/88	4.40 - 4.40	14 +/- 12 pci/g	25 +/- 12 pci/g	0.83 +/- 0.26 pci/g	0.67 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF10	WSF1001	05/05/88	0.50 - 0.50	3 +/- 6 pci/g	16 +/- 12 pci/g	0.83 +/- 0.26 pci/g	0.82 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF10	WSF1002	05/05/88	1.70 - 1.70	6 +/- 7 pci/g	19 +/- 13 pci/g	1.3 +/- 0.3 pci/g	1.3 +/- 0.2 pci/g	0.02 +/- 0.06 pci/g
WSF10	WSF1004	05/05/88	3.50 - 3.50	4 +/- 7 pci/g	20 +/- 12 pci/g	1.1 +/- 0.3 pci/g	0.96 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF11	WSF1101	05/05/88	0.50 - 0.50	3 +/- 7 pci/g	16 +/- 12 pci/g	0.73 +/- 0.26 pci/g	0.92 +/- 0.15 pci/g	0.02 +/- 0.06 pci/g
WSF11	WSF1102	05/05/88	2.00 - 2.00	4 +/- 7 pci/g	NR	0.95 +/- 0.26 pci/g	0.82 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF11	WSF1105	05/05/88	4.50 - 4.50	7 +/- 8 pci/g	19 +/- 11 pci/g	0.59 +/- 0.26 pci/g	0.71 +/- 0.15 pci/g	0.00 +/- 0.06 pci/g
WSF12	WSF1201	05/05/88	0.50 - 0.50	30 +/- 12 pci/g	29 +/- 13 pci/g	1.3 +/- 0.3 pci/g	1.4 +/- 0.2 pci/g	0.03 +/- 0.06 pci/g
WSF12	WSF1202	05/05/88	2.00 - 2.00	5 +/- 7 pci/g	79 +/- 13 pci/g	1.1 +/- 0.3 pci/g	1.1 +/- 0.2 pci/g	0.06 +/- 0.06 pci/g
WSF12	WSF1205	05/05/88	4.00 - 4.00	7 +/- 7 pci/g	72 +/- 12 pci/g	1.0 +/- 0.3 pci/g	0.94 +/- 0.2 pci/g	0.01 +/- 0.06 pci/g

TABLE 2-11

NITRATE RESULTS FROM TEST PITS (1988 SOILS DATA)

Sample No.	Depth (ft)	Nitrate as Nitrogen (mg/kg)
WSF0104	4.5	30
WSF0204	4.4	30
WSF0404	4.1	60
WSF0402	2.5	60
WSF0504	4.2	60
WSF0502	2.0	40
WSF0501	0.75	60
WSF0704	3.8	140
WSF0702	2.0	150
WSF1002	1.7	110
WSF1105	4.5	80
WSF1102	2.0	30
WSF1204	4.0	420

NOTE: Reported values for concentrations >20 mg/kg (detection limit)

T. 2-12
VOLATILE COMPOUNDS (1986 SOILS DATA)

SAMPLE TYPE	Sample Number	Acetone	PCE	MEC1	MEK	ChC1$_3$	CC1$_4$	TCE	Benzene	CS$_2$	Toluene	1,1,1-TCA	1,1,2-TCA
<u>WEST SPRAY FIELD SOILS</u>													
Surface Scrape	1D1	-	-	36B	-	-	-	-	-	-	-	-	-
(ug/kg)	2D1	25B	-	29B	-	-	-	-	-	-	21	-	-
	3D1	-	-	34B	-	-	-	-	-	2BJ	2J	-	-
0-6" (ug/kg)	1E1	-	-	37B	-	2J	-	-	-	-	-	-	-
	2E1	14B	-	70B	-	-	-	-	-	-	-	-	-
	3E1	-	-	33B	-	-	-	-	-	2BJ	43	-	-
6-12" (ug/kg)	1F1	-	-	33B	-	-	-	-	-	-	-	2J	2J
	2F1	-	-	33B	-	27	-	-	-	2J	7	-	-
	3F1	29	-	29B	-	-	-	-	-	2BJ	-	-	-
<u>BUFFER ZONE SOILS</u>													
Surface Scrape	1A1	-	-	-	-	-	-	-	-	-	1BJ	-	-
(ug/kg)	2A1	10B	-	-	-	-	-	-	-	-	1BJ	-	-
	3A1	10B	-	-	-	-	-	-	-	-	1BJ	-	-
0-6" (ug/kg)	1B1	-	-	46B	-	-	-	-	-	3BJ	-	-	-
	2B1	-	-	32B	-	-	-	-	-	2BJ	-	-	-
	3B1	-	-	32B	20	-	-	-	-	2BJ	-	-	-
6-12" (ug/kg)	1C1	130	-	39B	61	-	-	-	-	3BJ	3J	-	-
	2C1 NA	-	-	-	-	-	-	-	-	-	-	-	-
	3C1	71	-	28B	26	-	-	-	-	-	-	-	-

J = Estimated Value Below the detection limit
B = Analyte was found in blank as well as the sample indicating possible blank contamination
"-" = Value below detection limit

TABLE 2-13

VOLATILE COMPOUNDS FROM TEST PITS
(1988 SOILS DATA)
WEST SPRAY FIELD TEST PITS

Sample No.	Sample Depth (ft)	Acetone Value (ug/kg)	TCE Value (ug/kg)
WSF0402	2.5	16	-
WSF0404	4.1	78	-
WSF0501	0.75	7J	-
WSF0504	4.2	89	-
WSF0601	0.7	16	-
WSF0602	2.1	41	21
WSF0605	4.6	34	-
WSF0702	2.0	15	-
WSF0704	3.8	6J	-
WSF0801	0.65	5J	-
WSF0802	2.0	9J	-
WSF1105	4.5	33	-
WSF1201	0.5	-	23
WSF1202	2.0	30	-
WSF1204	4.0	6J	-

NOTE: Reported values for concentrations above the detection limit.

"-" Denotes reported value at the detection limit.
"J" Denotes value estimated below the detection limit.
TCE=Trichloroethene

TABLE 2-14

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND ROCKY FLATS ALLUVIAL GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Aluminum (Al)	23	4	17	.	.	2.3283	0.0835	0.0311	.	.	.	.	NORMAL
2	Antimony (Sb)	29	0	0	.	.	2.2324	0.0670	0.0851	.	.	.	.	NORMAL
3	Arsenic (As)	21	0	0	.	.	2.3714	0.0038	0.0019	.	.	.	.	NORMAL
4	Barium (Ba)	30	8	27	.	.	2.2198	0.0951	0.0119	.	.	.	.	NORMAL
5	Beryllium (Be)	22	0	0	.	.	2.3490	0.0020	0.0007	.	.	.	.	NORMAL
6	Cadmium (Cd)	30	2	7	.	.	2.2198	0.0028	0.0017	.	.	.	.	NORMAL
7	Calcium (Ca)	30	30	100	.	43.5726	2.2198	36.6861	3.1023	.	.	.	.	LOG
8	Cesium (Cs)	29	0	0	.	.	2.2324	0.4466	0.2343	.	.	.	.	NORMAL
9	Chromium (Cr)	25	1	4	.	.	2.2917	0.0061	0.0021	.	.	.	.	NORMAL
10	Cobalt (Co)	30	0	0	.	.	2.2198	0.0218	0.0060	.	.	.	.	NORMAL
11	Copper (Cu)	27	1	4	.	.	2.2600	0.0116	0.0033	.	.	.	.	NORMAL
12	Iron (Fe)	27	7	26	.	.	2.2600	0.0706	0.0576	.	.	.	.	NORMAL
13	Lead (Pb)	29	2	7	.	.	2.2324	0.0022	0.0008	.	.	.	.	NORMAL
14	Lithium (Li)	26	5	19	.	.	2.2753	0.0402	0.0184	.	.	.	.	NORMAL
15	Magnesium (Mg)	30	13	43	.	.	2.2198	3.5688	0.2361	.	.	.	.	LOG
16	Manganese (Mn)	29	21	72	.	0.1356	2.2324	0.0560	0.0164	0.0706	0.0291	0.32	0.37	LOG
17	Mercury (Hg)	24	0	0	.	.	2.3093	0.0001	0.0000	.	.	.	.	NORMAL
18	Molybdenum(Mo)	30	1	3	.	.	2.2198	0.0797	0.0782	.	.	.	.	NORMAL
19	Nickel (Ni)	27	2	7	.	.	2.2600	0.0188	0.0065	.	.	.	.	NORMAL
20	Potassium (K)	25	7	28	.	.	2.2917	2.2882	1.3731	.	.	.	.	NORMAL
21	Selenium (Se)	27	1	4	.	.	2.2600	0.0033	0.0047	.	.	.	.	NORMAL
22	Silver (Ag)	29	0	0	.	.	2.2324	0.0065	0.0040	.	.	.	.	NORMAL
23	Sodium (Na)	30	28	93	.	8.8696	2.2198	7.7573	0.5011	.	.	.	.	LOG
24	Strontium (Sr)	30	10	33	.	.	2.2198	0.3513	0.1872	.	.	.	.	NORMAL
25	Thallium (Tl)	28	0	0	.	.	2.2458	0.0058	0.0052	.	.	.	.	NORMAL
26	Tin (Sn)	28	0	0	.	.	2.2458	0.1375	0.1762	.	.	.	.	NORMAL
27	Vanadium (V)	29	0	0	.	.	2.2324	0.0210	0.0077	.	.	.	.	NORMAL
28	Zinc (Zn)	23	11	48	.	.	2.3283	0.0258	0.0290	.	.	.	.	NORMAL

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable

Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-14

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND ROCKY FLATS ALLUVIAL GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Bicarbonate	36	36	100	.	146.7346	2.1577	125.6275	9.7824	.	.	.	.	LOG
2	Carbonate	35	0	0	.	.	2.1667	2.5000	0.0000	.	.	.	.	NORMAL
3	Cyanide	26	2	8	.	.	2.2753	0.0032	0.0018	.	.	.	.	NORMAL
4	Dissolved Solids	36	36	100	.	235.7493	2.1577	209.3996	12.2121	.	.	.	.	LOG
5	Field pH	38	38	100	6.0781	8.3193	2.1408	7.1987	0.5234	.	.	.	.	NORMAL
6	Nitrate/Nitrite	36	36	100	.	2.1734	2.1577	1.6568	0.2394	.	.	.	.	LOG
7	Sulfate	36	36	100	.	25.2270	2.1577	22.6385	1.1997	.	.	.	.	LOG

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable
Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-14

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND ROCKY FLATS ALLUVIAL GROUND WATER SAMPLES

(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Chloride	15	15	100	.	7.5743	2.5660	5.7419	0.7141	.	.	.	.	LOG

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable

Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-14

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND ROCKY FLATS ALLUVIAL GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Chloride	21	17	81	.	11.0388	2.3714	6.9998	1.2660	7.1788	1.6277	0.10	0.26	LOG

NORMAL=Normal data distribution assumed   LOG=Log normal data distribution assumed   . = result is not applicable
Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-14

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND ROCKY FLATS ALLUVIAL GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Americium-241	24	24	100	.	0.0197	2.3093	0.0025	0.0074	.	.	.	.	NORMAL
2	Cesium-137	28	28	100	.	0.6237	2.2458	0.0936	0.2361	.	.	.	.	NORMAL
3	Gross Alpha	28	28	100	.	7.7990	2.2458	2.0179	2.5742	.	.	.	.	NORMAL
4	Gross Beta	28	28	100	.	8.7694	2.2458	2.4857	2.7980	.	.	.	.	NORMAL
5	Plutonium-239	27	27	100	.	0.0118	2.2600	0.0019	0.0044	.	.	.	.	NORMAL
6	Radium-226	6	6	100	.	.	3.7077	28.5708	69.2861	.	.	.	.	NORMAL
7	Strontium-90	28	28	100	.	1.2300	2.2458	0.1286	0.4904	.	.	.	.	NORMAL
8	Tritium	27	27	100	.	454.2380	2.2600	110.3704	152.1508	.	.	.	.	NORMAL
9	Uranium-235	28	28	100	.	0.1601	2.2458	0.0221	0.0614	.	.	.	.	NORMAL
10	Uranium-238	28	28	100	.	0.9806	2.2458	0.2654	0.3185	.	.	.	.	NORMAL

NORMAL=normal data distribution assumed LOG=log normal data distribution assumed . result is not applicable

Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-15

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUND WATER SAMPLES

(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Aluminum (Al)	13	1	8	.	.	2.6705	0.1109	0.0690	.	.	.	.	NORMAL
2	Antimony (Sb)	19	0	0	.	.	2.4230	0.0647	0.0824	.	.	.	.	NORMAL
3	Arsenic (As)	20	3	15	.	.	2.3960	0.0055	0.0036	.	.	.	.	NORMAL
4	Barium (Ba)	20	2	10	.	.	2.3960	0.0947	0.0171	.	.	.	.	NORMAL
5	Beryllium (Be)	18	0	0	.	.	2.4529	0.0023	0.0006	.	.	.	.	NORMAL
6	Cadmium (Cd)	17	0	0	.	.	2.4863	0.0024	0.0002	.	.	.	.	NORMAL
7	Calcium (Ca)	20	18	90	.	38.8630	2.3960	24.4479	6.0163	.	.	.	.	LOG
8	Cesium (Cs)	20	0	0	.	.	2.3960	0.4925	0.2255	.	.	.	.	NORMAL
9	Chromium (Cr)	16	1	6	.	.	2.5237	0.0067	0.0035	.	.	.	.	NORMAL
10	Cobalt (Co)	20	0	0	.	.	2.3960	0.0228	0.0055	.	.	.	.	NORMAL
11	Copper (Cu)	19	2	11	.	.	2.4230	0.0166	0.0140	.	.	.	.	NORMAL
12	Iron (Fe)	19	3	16	.	.	2.4230	0.0489	0.0043	.	.	.	.	NORMAL
13	Lead (Pb)	20	2	10	.	.	2.3960	0.0055	0.0059	.	.	.	.	NORMAL
14	Lithium (Li)	20	5	25	.	.	2.3960	0.0624	0.0538	.	.	.	.	NORMAL
15	Magnesium (Mg)	20	7	35	.	.	2.3960	4.2178	0.7074	.	.	.	.	LOG
16	Manganese (Mn)	19	6	32	.	.	2.4230	0.0167	0.0035	.	.	.	.	LOG
17	Mercury (Hg)	19	5	26	.	.	2.4230	0.0001	0.0001	.	.	.	.	NORMAL
18	Molybdenum (Mo)	20	2	10	.	.	2.3960	0.0859	0.0730	.	.	.	.	NORMAL
19	Nickel (Ni)	17	0	0	.	.	2.4863	0.0182	0.0039	.	.	.	.	NORMAL
20	Potassium (K)	19	9	47	.	.	2.4230	5.9247	6.0886	.	.	.	.	NORMAL
21	Selenium (Se)	19	6	32	.	.	2.4230	0.0062	0.0094	.	.	.	.	NORMAL
22	Silver (Ag)	19	0	0	.	.	2.4230	0.0066	0.0037	.	.	.	.	NORMAL
23	Sodium (Na)	20	20	100	.	213.3108	2.3960	155.9665	23.9334	.	.	.	.	LOG
24	Strontium (Sr)	20	8	40	.	.	2.3960	0.5658	0.2773	.	.	.	.	NORMAL
25	Thallium (Tl)	19	0	0	.	.	2.4230	0.0063	0.0050	.	.	.	.	NORMAL
26	Tin (Sn)	20	0	0	.	.	2.3960	0.1175	0.1649	.	.	.	.	NORMAL
27	Vanadium (V)	17	0	0	.	.	2.4863	0.0215	0.0079	.	.	.	.	NORMAL
28	Zinc (Zn)	17	10	59	.	0.2582	2.4863	0.0440	0.0861	.	.	3.49	.	NORMAL

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable

Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-15

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Bicarbonate	13	13	100	.	302.2308	2.6705	255.6284	17.4508	.	.	.	.	LOG
2	Carbonate	13	9	69	.	30.1793	2.6705	8.0692	6.7488	6.3774	8.9129	0.71	0.52	NORMAL
3	Cyanide	11	2	18	.	.	2.8150	0.0037	0.0017	.	.	.	.	NORMAL
4	Dissolved Solids	13	13	100	.	728.1007	2.6705	496.7785	86.6212	.	.	.	.	LOG
5	Field pH	20	20	100	7.2917	10.6483	2.3960	8.9700	0.7005	.	.	.	.	NORMAL
6	Nitrate/Nitrite	12	6	50	.	.	2.7363	0.3358	0.1948	0.7294	0.6543	0.49	0.98	LOG
7	Sulfate	13	8	62	.	290.9021	2.6705	49.5886	29.8358	88.9962	75.6059	0.55	0.72	LOG

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable
Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-15

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUND WATER SAMPLES
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Chloride	6	6	100	.	.	3.7077	23.8698	14.1990	.	.	.	.	LOG

NORMAL=Normal data distribution assumed   LOG=Log normal data distribution assumed   . = result is not applicable
Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-15

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUND WATER SAMPLES

(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Chloride	7	7	100	.	412.3540	3.3995	159.6799	74.3275	.	.	.	.	LOG

NORMAL=Normal data distribution assumed LOG=Log normal data distribution assumed . = result is not applicable
Statistics for log normal distributions are presented as untransformed (antilog) values.

TABLE 2-15

TOLERANCE INTERVAL CALCULATIONS FOR DISSOLVED METAL CONCENTRATIONS IN BACKGROUND UNWEATHERED SANDSTONE GROUND WATER SAMPLES

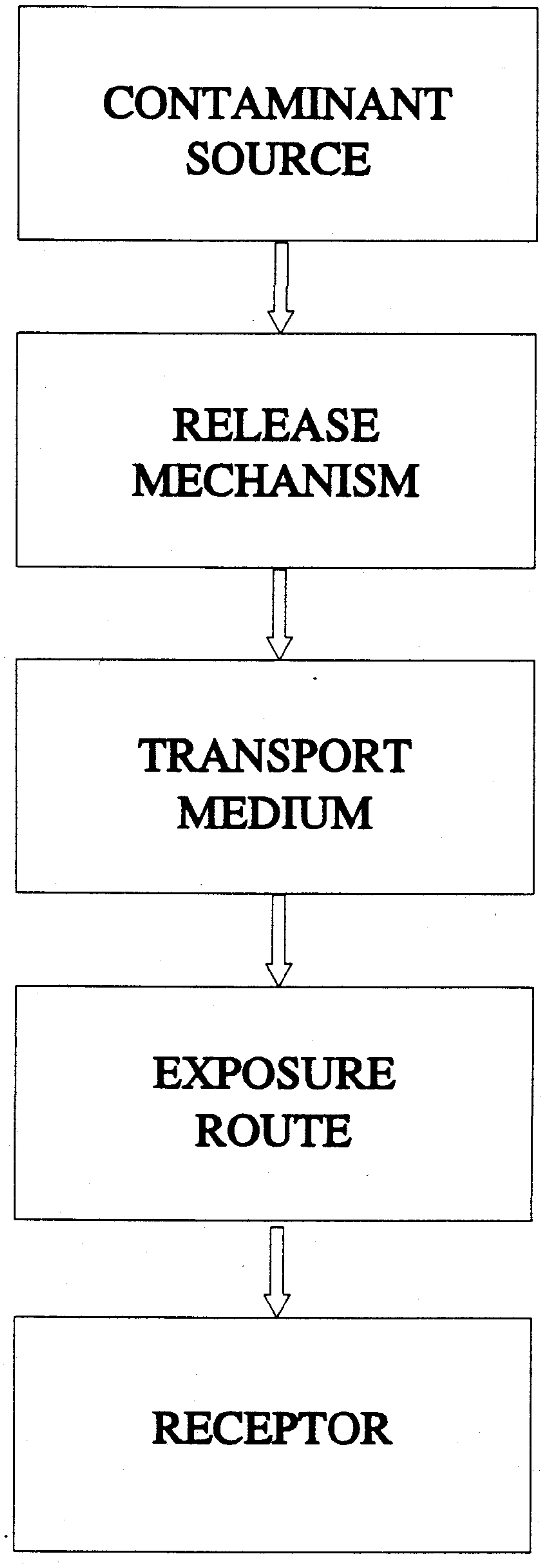
(Concentration units mg/l)

	Analyte	No. of Samples	No. of Detects	Percent Detects	Lower Tolerance Interval	Upper Tolerance Interval	Tolerance Factor	Mean	Standard Deviation	Cohen Revised Mean	Cohen Revised Standard Deviation	Cohen Tau	Cohen Lambda	Data Distribution
1	Americium-241	15	15	100	.	0.0636	2.5660	0.0091	0.0213	.	.	.	.	NORMAL
2	Cesium-137	20	20	100	.	0.8192	2.3960	0.1040	0.2985	.	.	.	.	NORMAL
3	Gross Alpha	19	19	100	.	28.4866	2.4230	5.4947	9.4889	.	.	.	.	NORMAL
4	Gross Beta	20	20	100	.	33.4236	2.3960	10.0800	9.7427	.	.	.	.	NORMAL
5	Plutonium-239	19	19	100	.	0.0109	2.4230	0.0023	0.0036	.	.	.	.	NORMAL
6	Radium-226	2	2	100	.	.	26.2597	0.4000	0.2828	.	.	.	.	NORMAL
7	Strontium-90	20	20	100	.	0.9283	2.3960	0.1650	0.3186	.	.	.	.	NORMAL
8	Tritium	20	20	100	.	495.8059	2.3960	-25.0000	217.3646	.	.	.	.	NORMAL
9	Uranium-235	20	20	100	.	1.0681	2.3960	0.1580	0.3799	.	.	.	.	NORMAL
10	Uranium-238	20	20	100	.	7.0858	2.3960	1.0135	2.5343	.	.	.	.	NORMAL

NORMAL=normal data distribution assumed LOG=log normal data distribution assumed . result is not applicable

statistics for log normal distributions are presented as untransformed (antilog) values.

FIGURE 2-9
COMPONENTS OF A COMPLETED EXPOSURE PATHWAY



Source: RCRA RFI/RI Workplan for OU3, July 1991

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000011

Titled: Operable Unit No. 11, Phase I RFI/RI Work Plan IHSS 168 Boundary and Spray Areas Plate 2-1

Fiche location: A-OU11-M1

3.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

The purpose of this section is to provide a preliminary list of potential-chemical specific Applicable or Relevant and Appropriate Requirements (ARARs) for surface and groundwater contamination at the West Spray Field, Operable Unit 11. This section includes a summary of potential chemical-specific ARARs based upon current Colorado and federal environmental statutes and regulations. During the Phase I portion of the RFI/RI, the summary will be used to ensure that appropriate detection limits have been established and that collected data will be amenable for comparison to ARARs. ARARs are being used as a screening mechanism to establish analytical detection limits for chemical constituents that may have been released at the site. The analytical methods selected based on the established detection limit will in turn be used to determine the type and concentration of the contaminant released, the rate and direction at which the release is migrating, and the distance over which the release has already migrated.

Operable Unit 11 is subject to the Colorado Hazardous Waste Act, §§ 25-15-101 et seq., C.R.S. (1990) and the Resource Conservation and Recovery Act (RCRA), 42 U.S.C. §§ 6901 et seq., and cleanup standards will be developed based upon a risk level of less than 1×10^{-6}. As data become available during the Phase I RFI/RI process, specific cleanup levels for each contaminant will be proposed based upon this risk level. The CMS/FS report will further address chemical-specific ARARs as well as action-specific and location specific ARARs in developing and evaluating remedial alternatives.

3.1 THE ARAR BASIS

The basis for ARARs may be found in the section 121(d) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended. This section requires that

CERCLA-financed, enforcement, and federal facility remedial actions comply with federal ARARS or more stringent state requirements.

3.2 THE ARAR PROCESS

A screening and analysis process will be used to determine which of the potential ARARs will be applied to Operable Unit 11. The analysis will address compliance with chemical-specific, location-specific, and action-specific ARARs in accordance with the National Contingency Plan (NCP). This screening process will consider relevant and appropriate requirements in the same manner as applicable requirements. When more than one ARAR is identified, the more stringent of the applicable ARARs will be used.

The first step in identifying potential ARARs will occur after the initial scoping and site characterization. It will require analysis of contaminants present at the site and any unique characteristics specific to the site. After the chemicals have been identified, the presence or absence of chemical-specific ARARs will be determined. Chemical-specific ARARs will be derived primarily from Colorado and federal environmental statutes and regulations, including the following:

- Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs) potentially applicable to surface and groundwater;
- Clean Water Act (CWA) ambient water quality criteria (AWQC) potentially applicable to surface and alluvial groundwater;
- RCRA maximum concentration of constituents for groundwater protection (40 CFR §264.94) applicable to groundwater;

- Colorado Department of Health (CDH)/Colorado Water Quality Control Commission (CWQCC) surface water standards for Woman Creek and Walnut Creek (5 CCR 1002-8, §3.8.29) applicable to surface water;

- CDH/CWQCC basic standards for groundwater (5 CCR 1002-8, §3.11.0) potentially applicable to groundwater; and

- CDH/CWQCC classifications and water quality standards for groundwater (5 CCR 1002-8, §3.12.0) potentially applicable to groundwater.

A summary of chemical-specific standards or potential ARARs is presented in Table 3-1, "Groundwater Quality Standards;" Table 3-2, "Federal Surface Water Quality Standards;" and Table 3-3, "State (CDH/CWQCC) Surface Water Quality Standards."

Where ARARs do not exist for a particular chemical, to-be-considered (TBC) criteria (such as guidance, proposed standards, and advisories developed by federal or state agencies) will be evaluated for use. Where ARARs or TBC criteria are not available or are less than laboratory practical quantitation limits (PQLs), PQLs will be used. Where no prescribed methods exist, methods that achieve the detection limits provided in the General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1991e), which are contract laboratory program (CLP) contract-required quantitation limits, will be utilized.

3.2.1 ARARs

Title 40 CFR §300.5 defines "applicable requirements" as "those standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."

"Relevant and appropriate requirements," also defined in 40 CFR §300.5, are "those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate." The most stringent promulgated standards are applied as ARARs (Preamble to NCP; 55 FR 8741). According to 40 CFR §300.400(g)(4), the term "promulgated" refers to standards that are generally applicable and legally enforceable.

3.2.2 To-Be-Considered (TBC) Criteria

TBCs may be applied at a site. According to 40 CFR §300.400(g)(3), TBCs include advisories, criteria, or guidance developed by EPA, other federal agencies or states that may be useful in developing remedies. The use of TBCs is discretionary.

3.2.3 ARAR Categories

There are three basic types of ARARs:

- ambient or chemical-specific requirements;
- location-specific requirements; and
- performance, design, or other action-specific requirements.

ARARs are generally considered to be dynamic in nature in that they evolve from general to very specific in the CERCLA site cleanup process. Initially, during the RFI/RI Work Plan stage, probable chemical-specific ARARs may be identified, usually on the basis of limited data. Chemical-specific ARARs at this point have meaning only in that they can be used to ensure that appropriate detection limits have been established so that data collected in the RFI/RI will be amenable for comparison to ARAR standards. It is also appropriate to identify location-specific ARARs early in the RFI/RI process so that information can be gathered to determine whether restrictions can be placed on the concentrations of hazardous substances or on the conduct of an activity solely because it occurs in a special location.

Detailed, location-specific ARARs will be proposed in the RFI/RI report. Identification of action-specific ARARs and remediation goals is part of the feasibility study process and will be addressed in the CMS/FS report. Chemical-specific ARARs may be deleted if they are found to be inappropriate at any time in the RFI/RI process. Deletion of chemical-specific ARARs will be based on analytical information obtained from sampling at Operable Unit 11.

One medium for which chemical-specific ARARs do not currently exist is soils; however, some chemical-related, action-specific requirements do exist, such as Colorado's construction standard for plutonium in soils. Relative to chemical-specific ARARs, a Baseline Risk Assessment will be performed to determine acceptable contaminant concentrations in soils to ensure environmental protection. At this time, method detection limits provided in GRRASP (EG&G, 1991e) will be used to interpret soil sample results.

For appropriate management of investigation-derived wastes, as required in the IAG (Attachment 2, Statement of Work, Section IV), DOE has developed standard operating procedures (SOPs) for field investigation activities. All waste generated by the various investigations conducted at the RFP will follow SOPs approved by EPA and CDH. These SOPs satisfy the IAG requirement to comply with ARARs as they relate to investigation activities. This approach is consistent with EPA policy as provided in the Draft Guide to Management of Investigation-Derived Waste (U.S. EPA, 1991).

3.2.4 Remedial Action

CERCLA §121 specifically requires attainment of all ARARs. More over, a remedial action must comply with the most stringent requirement, which then ensures attainment of all other ARARs. CERCLA also requires that the remedies selected attain ARARs and be protective of human health and the environment. Remediation goals will be based on the Baseline Risk Assessment to be conducted for protection of human health and the environment.

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Bicarbonate	A	10	E310.1													
Carbonate	A	10	E310.1													
Chloride	A	5	E325	250,000 *							250,000					
Chlorine	A	1000	E4500													
Fluoride	A	5	E340	4,000; 2,000*		4,000				4,000		2,000				
N as Nitrate	A	5	E353.1	10,000			10,000			10,000						
N as Nitrate + Nitrite	A	5	E353.1		10,000		10,000					100,000				
N as Nitrite	A	5	E354.1		1,000		1,000			1,000		10,000				
Sulfate	A	5	E375.4	250,000*							250,000					
Sulfide	A															
Coliform (total)	B	1	SM9221C	1/100 ml						1/100 ml						
Ammonia as N	C	5	E350													
Dioxin	D		d						0.00000022 (7)					0.0000000		
Sulfur	E	100,000	E600													
Dissolved Oxygen	FP	0.5	SM4500													
pH	FP	0.1	E150.1	6.5-8.5 *							6.5-8.5	6.5-8.5				
Specific Conductance	FP	1	E120.1													
Temperature	FP															
Boron	I	5	E6010									750				
Total Dissolved Solids	I	10	E160.1	500,000*									400,000 (1			
Aluminum	M	200	CT		50 to 200*							5,000				
Antimony	M	60	CT													

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Arsenic	M	10	CT	50				50		50		100				
Arsenic III	M															
Arsenic V	M															
Barium	M	200	CT	1,000	2,000 (e)		2,000 (e)	1,000		1,000						
Beryllium	M	5	CT									100				
Cadmium	M	5	CT	10	5		5	10		10		10				
Calcium	M	5,000	CT													
Cesium	M	1,000	NC													
Chromium	M	10	CT	50	100		100	50		50		100				
Chromium III	M	5	SW846719													
Chromium VI	M	10	E218.5													
Cobalt	M	50	CT									50				
Copper	M	25	CT	1,000 *			1300 (f)				1,000	200				
Cyanide	M	10	CT							200						
Iron	M	100	CT	300 *							300	5,000				
Lead	M	5	CT	50			0 (f)	50		50		100				
Lithium	M	100	NC									2,500				
Magnesium	M	5000	CT													
Manganese	M	15	CT	50 *							50	200				
Mercury	M	0.2	CT	2	2		2	2		2		10				
Molybdenum	M	200	NC													
Nickel	M	40	CT									200				
Potassium	M	5000	CT													
Selenium	M	5	CT	10	50		50	10		10		20				
Silver	M	10	CT	50	100 *			50		50						

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Sodium	M	5000	CT													
Strontium	M	200	NC													
Thallium	M	10	CT													
Tin	M	200	NC													
Titanium	M	10	E6010													
Tungsten	M	10	E6010													
Vanadium	M	50	CT									100				
Zinc	M	20	CT	5,000 *							5,000	2,000				
2,4,5-TP Silvex	P		d	10	50		50	10	10							
2,4-Dichlorophenoxyacetic A	P		d	100	70		70	100	100							
(2,4-D)	P															
Aldicarb	P				3 (e)		1 (e)		10							
Aldrin	P	0.05	CP						0.002 (7)					0.0000784		
Bromacil	P															
Carbofuran	P		d		40		40		36							
Chloranil	P															
Chlordane (Alpha)	P	0.5	CP		2		0		0.03 (7)					0.00046		
Chlordane (Gamma)	P	0.5	CP		2		0		0.03 (7)					0.00046		
Chlorpyrifos	P		E619													
DDT	P	0.1	CP						0.1 (7)					0.000024		
DDT Metabolite (DDD)	P	0.1	CP													
DDT Metabolite (DDE)	P	0.1	CP													
Demeton	P															
Diazinon	P															

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

Parameter	Type (5)	PQL MDL	Method (6)	FEDERAL STANDARDS: SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	STATE STANDARDS (TBCs) – CDH/CWQCC Groundwater Quality Standards (d): Statewide Tables A & B (d)	Site-Specific (g): Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Dieldrin	P	0.1	CP						0.002 (7)					0.000071		
Endosulfan I	P	0.05	CP													
Endosulfan II	P	0.1	CP													
Endosulfan sulfate	P	0.1	CP													
Endrin	P	0.1	CP	0.2				0.2	0.2							
Endrin Ketone	P	0.1	CP													
Guthion	P															
Heptachlor	P	0.05	CP		0.4		0		0.008 (7)					0.00028		
Heptachlor Epoxide	P	0.05	CP		0.2		0		0.004 (7)							
Hexachlorocyclohexane, Alp	P	0.05	CP											0.0092		
Hexachlorocyclohexane, Bet	P	0.05	CP											0.0163		
Hexachlorocyclohexane, Delt	P	0.05	CP													
Hexachlorocyclohexane, Tec	P		f											0.0123		
Hexachlorocyclohexane, Lin	P	0.05	CP	4	0.2		0.2	4.0	4					0.0186		
Malathion	P															
Methoxychlor	P	0.5	CP	100	40		40	100	100							
Mirex	P															
Parathion	P															
PCBs	P	0.5	CP		0.5		0		0.005 (7)					0.000079		
Simazine	P		e											4.0		
Toxaphene	P	1	CP		3		0	5.0	5							
Vaponite 2	P															
Aroclor 1016	PP	0.5	CP													
Aroclor 1221	PP	0.5	CP													
Aroclor 1232	PP	0.5	CP													

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Aroclor 1242	PP	0.5	CP													
Aroclor 1248	PP	0.5	CP													
Aroclor 1254	PP	1	CP													
Aroclor 1260	PP	1	CP													
Atrazine	PP		e		3		3							3.0		
Americium (pCi/l)	R														0.05	0.05
Americium 241 (pCi/l)	R	0.01														
Cesium 134 (pCi/l)	R	1							80 (2)						80	80
Cesium 137 (pCi/l)	R	1														
Gross Alpha (pCi/l)	R	2		15 (8)						15					7	11
Gross Beta (pCi/l)	R	4		50 (4 mrem/yr)						4 mrem/yr					5	19
Plutonium 238+239+240 (p	R	0.01							15 (2)							
Plutonium (pCi/l)	R														0.05	0.05
Radium 226+228 (pCi/l)	R	0.5/1.0 (		5					5 (2)							
Strontium 89+90 (pCi/l)	R	1														
Strontium 90 (pCi/l)	R			8 (3)					8 (2)						8	8
Thorium 230+232 (pCi/l)	R								60 (2)							
Tritium (pCi/l)	R			20,000 (3)					20,000 (2)						500	500
Uranium 233+234 (pCi/l)	R															
Uranium 235 (pCi/l)	R	0.6														
Uranium 238 (pCi/l)	R	0.6														
Uranium (Total) (pCi/l)	R														5	10
1,2,4,5-Tetrachlorobenzene	SV		b						2 (7)							

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
				SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 8 Radionuclides	
Parameter	Type (5)	PQL MDL	Method (6)												Woman Creek	Walnut Creek
1,2,4-Trichlorobenzene	SV	10	CS													
1,2-Dichlorobenzene (Ortho)	SV	10	CS		600		600		620							
1,2-Diphenylhydrazine	SV		b						0.05 (7)							
1,3-Dichlorobenzene (Meta)	SV	10	CS						620							
1,4-Dichlorobenzene (Para)	SV	10	CS	75		75			75							
2,4,5-Trichlorophenol	SV	50	CS						700							
2,4,6-Trichlorophenol	SV	10	CS						2 (7)					1.2		
2,4-Dichlorophenol	SV	10	CS						21							
2,4-Dimethylphenol	SV	10	CS													
2,4-Dinitrophenol	SV	50	CS													
2,4-Dinitrotoluene	SV	10	CS													
2-Chloronaphthalene	SV	10	CS													
2-Chlorophenol	SV	10	CS													
2-Methylnaphthalene	SV	10	CS													
2-Methylphenol	SV	10	CS													
2-Nitroaniline	SV	50	CS													
2-Nitrophenol	SV	10	CS													
3,3-Dichlorobenzidine	SV	20	CS													
3-Nitroaniline	SV	50	CS													
4,6-Dinitro-2-methylphenol	SV	50	CS													
4-Bromophenyl Phenylether	SV	10	CS													
4-Chloroaniline	SV	10	CS													
4-Chlorophenyl Phenyl Ether	SV	10	CS													
4-Chloro-3-methylphenol	SV	10	CS													
4-Methylphenol	SV	10	CS													
4-Nitroaniline	SV	50	CS													
4-Nitrophenol	SV	50	CS													
Acenaphthene	SV	10	CS													
Anthracene	SV	10	CS													
Benzidine	SV		d						0.0002 (7)					0.00012		

TABLE 3-1
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GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek
Benzoic Acid	SV	50	CS													
Benzo(a)anthracene	SV	10	CS													
Benzo(a)pyrene	SV	10	CS													
Benzo(b)fluoranthene	SV	10	CS													
Benzo(g,h,i)perylene	SV	10	CS													
Benzo(k)fluoranthene	SV	10	CS													
Benzyl Alcohol	SV	10	CS													
bis(2-Chloroethoxy)methane	SV	10	CS													
bis(2-Chloroethyl)ether	SV	10	CS						0.03 (7)					0.0000037		
bis(2-Chloroisopropyl)ether	SV	10	CS													
bis(2-Ethylhexyl)phthalate	SV	10	CS													
Butadiene	SV															
Butylbenzylphthalate	SV	10	CS													
Chlorinated Ethers	SV															
Chlorinated Napthalenes	SV															
Chloroalkylethers	SV	10	CS													
Chlorophenol	SV									1						
Chrysene	SV	10	CS													
Dibenzofuran	SV	10	CS													
Dibenz(a,h)anthracene	SV	10	CS													
Dichlorobenzenes	SV															
Dichlorobenzidine	SV	20	CS											0.01		
Diethylphthalate	SV	10	CS													
Dimethylphthalate	SV	10	CS													
Dinitrotoluene	SV	10	CS													
Di-n-butylphthalate	SV	10	CS													
Di-n-octylphthalate	SV	10	CS													
Ethylene Glycol	SV		d						7,000							
Fluoranthene	SV	10	CS													
Fluorene	SV	10	CS													
Formaldehyde	SV															
Haloethers	SV															
Hexachlorobenzene	SV	10	CS						0.02 (7)					0.00072		
Hexachlorobutadiene	SV	10	CS						14					0.45		
Hexachlorocyclopentadiene	SV	10	CS						49							
Hexachloroethane	SV	10	CS											1.9		
Hydrazine	SV															
Indeno(1,2,3-cd)pyrene	SV	10	CS													
Isophorone	SV	10	CS						1,050							
Naphthalene	SV	10	CS													

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
				SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Statewide	Site-Specific (g)						
									Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides	
Parameter	Type (5)	PQL MDL	Method (6)												Woman Creek	Walnut Creek
Nitrobenzene	SV	10	CS						3.5 (7)							
Nitrophenols	SV															
Nitrosamines	SV															
Nitrosodibutylamine	SV		b											0.0064		
Nitrosodiethylamine	SV		b											0.0008		
Nitrosodimethylamine	SV		b											0.0014		
Nitrosopyrrolidine	SV		b											0.016		
N-Nitrosodiphenylamine	SV	10	CSb											4.9		
N-Nitroso-di-n-dipropylamine	SV	10	CSb													
Pentachlorinated Ethanes	SV		b													
Pentachlorobenzene	SV		b						6 (7)							
Pentachlorophenol	SV	50	CS		1 (e)		0 (e)		200							
Phenanthrene	SV	10	CS													
Phenol	SV	10	CS							1						
Phthalate Esters	SV															
Polynuclear Aromatic Hydroc	SV		b											0.0028		
Vinyl Chloride	SV	10	CV	2		0			2							
1,1,1-Trichloroethane	V	5	CV	200		200			200							
1,1,2,2-Tetrachloroethane	V	5	CV											0.17		
1,1,2-Trichloroethane	V	5	CV						28							
1,1-Dichloroethane	V	5	CV											0.6		
1,1-Dichloroethene	V	5	CV	7		7			7							
1,2-Dichloroethane	V	5	CV	5		0			5							
1,2-Dichloroethene (cis)	V		a		70		70		70							
1,2-Dichloroethene (total)	V	5	CV													
1,2-Dichloroethene (trans)	V		a		100		100		70							
1,2-Dichloropropane	V	5	CV		5		0		0.56 (7)							
1,3-Dichloropropene (cis)	V	5	CV													
1,3-Dichloropropene (trans)	V	5	CV													
2-Butanone	V	10	CV													
2-Hexanone	V	10	CV													
4-Methyl-2-pentanone	V	10	CV													
Acetone	V	10	CV													
Acrylonitrile	V		c											0.058		
Benzene	V	5	CV	5		0			5							
Bromodichloromethane	V	5	CV													
Bromoform	V	5	CV													
Bromomethane	V	10	CV													
Carbon Disulfide	V	5	CV													

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
				SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides	
Parameter	Type (5)	PQL MDL	Method (6)												Woman Creek	Walnut Creek
Carbon Tetrachloride	V	5	CV	5		0			5							
Chlorinated Benzenes	V	10	CV/CS													
Chlorobenzene	V	5	CV/CS		100		100		300							
Chloroethane	V	10	CV													
Chloroform	V	5	CV	Tot THM <100**					Tot THM <100**					0.19		
Chloromethane	V	10	CV													
Dibromochloromethane	V	5	CV													
Dichloroethenes	V															
Ethyl Benzene	V	5	CV		700		700		680							
Ethylene Dibromide	V		d		0.05		0		0.0004							
Ethylene Oxide	V															
Halomethanes	V			100					100					0.19		
Methylene Chloride	V	5	CV													
Pyrene	V	10	CS													
Styrene	V	5	CV		100		100									
Tetrachloroethanes	V	5	CV													
Tetrachloroethene	V	5	CV		5		0		10					0.8		
Toluene	V	5	CV		1,000		1,000		2,420							
Trichloroethanes	V	5	CV													
Trichloroethene	V	5	CV	5		0			5							
Vinyl Acetate	V	10	CV													
Xylenes (total)	V	5	CV		10,000		10,000									

EXPLANATION OF TABLE

* = secondary maximum contaminant level; TBCs

** = total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane

CDH	= Colorado Department of Health
CLP	= Contract Laboratory Program
EPA	= Environmental Protection Agency
pCi/l	= picocuries per liter
PCB	= polychlorinated biphenyl
PQL	= Practical Quantitation Limit
RCRA	= Resource Conservation and Recovery Act
SDWA	= Safe Drinking Water Act
TAL	= Target Analyte List
THM	= Total Trihalomethanes
TIC	= Tentatively Identified Compound

TABLE 3-1
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
GROUNDWATER QUALITY STANDARDS (ug/l)

				FEDERAL STANDARDS					STATE STANDARDS (TBCs)							
									CDH/CWQCC Groundwater Quality Standards (d)							
									Statewide	Site-Specific (g)						
Parameter	Type (5)	PQL MDL	Method (6)	SDWA Maximum Contaminant Level TBCs (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	RCRA Subpart F Concentration Limit (40CFR264.94) (c)	Tables A & B (d)	Table 1 Human Health	Table 2 Secondary Drinking	Table 3 Agriculture	Table 4 TDS	Table 5 Chronic	Table 6 Radionuclides Woman Creek	Table 6 Radionuclides Walnut Creek

MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis
WQCC = Water Quality Control Commission

(1) TDS standard - see Table 4 in (d); standard is 400 mg/l or 1.25 times the background level, whichever is least restrictive
(2) radionuclide standards - see sec. 3.11.5(c)2 in (d)
(3) If both strontium-90 and tritium are present, the sum of their annual dose equivalents to bone marrow shall not exceed 4 mrem/yr.
(4) MDL for Radium 226 is 0.5; MDL for radium 228 is 1
(5) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; E=element; FP=field parameter; I=indicator; M=metal; P=pesticide; PP=pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile
(6) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TIC in CV;
d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.
(7) Standard is below (more stringent than) PQL, therefore PQL is standard.
(8) Value for gross alpha excludes uranium.

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of 5/1990)
(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective July 30, 1992 (56 FR 3526; 1/30/1991)
(c) NCP, 40 CFR 300; NCP Preamble 55 FR 8764; CERCLA Compliance with Other Laws Manual, EPA/540/G-89/006, August 1988
(d) CDH/Water Quality Control Commission, The Basic Standards for Ground Water, 3.11.0 (5 CCR 1002-8) 1/5/1987 amended 9/11/1990
(e) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, 143, Final Rule, Effective January 1, 1993 (56 FR 30266; 7/1/1991)
(f) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/91) effective 11/6/91.
(g) CDH/Water Quality Control Commission, Classifications and Water Quality Standards for Ground Water, 3.12.0 (3/5/1991).

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Bicarbonate	A	10	E310.1								
Carbonate	A	10	E310.1								
Chloride	A	5	E325	250,000*				860,000(e)	230,000(e)		
Chlorine	A	1000	E4500					19	11		
Flouride	A	5	E340	4,000; 2,000*		4,000					4,000
N as Nitrate	A	5	E353.1	10,000			10,000			10,000	
N as Nitrate+Nitrite	A	5	E353.1		10,000		10,000				
N as Nitrite	A	5	E354.1		1,000		1,000				
Sulfate	A	5	E375.4	250,000*							
Sulfide	A										
Coliform (Fecal)	B	1	SM9221C	1/100 ml							
Ammonia as N	C	5	E350					Criteria are pH and t			
Dioxin	D		d					0.01	0.00001	0.000000013	0.000000014
Sulfur	E	100,000	E600								
Dissolved Oxygen	FP	0.5	SM4500					5,000			
pH	FP	0.1	E150.1	6.5-8.5 *					6.5-9		
Specific Conductance	FP	1	E120.1								
Temperature	FP							SS	SS		
Boron	I	5	E6010								
Total Dissolved Solids	I	10	E160.1	500,000*				SS	SS	250,000	
Aluminum	M	200	CT		50 to 200*			750	87		
Antimony	M	60	CT					9,000	1,600	146	45,000
Arsenic	M	10	CT	50						.0022	.0175
Arsenic III	M							360	190		
Arsenic V	M							850	48		
Barium	M	200	CT	1,000	2,000 (f)		2,000 (f)			1,000	
Beryllium	M	5	CT					130	5.3	.0068**	.117**
Cadmium	M	5	CT	10	5		5	3.9 (3)	1.1 (3)	10	
Calcium	M	5,000	CT								
Cesium	M	1,000	NC								
Chromium	M	10	CT	50	100		100				
Chromium III	M	5	SW84671					1,700	210	170,000	3,433,000
Chromium VI	M	10	E218.5					16	11	50	
Cobalt	M	50	CT								
Copper	M	25	CT	1,000*			1,300 (f)	18 (3)	12 (3)		
Cyanide	M	10	CT					22	5.2	200	
Iron	M	100	CT	300 *					1,000	300	
Lead	M	5	CT	50			0 (g)	82 (3)	3.2 (3)	50	
Lithium	M	100	NC								
Magnesium	M	5000	CT								
Manganese	M	15	CT	50 *						50	100
Mercury	M	0.2	CT	2	2		2	2.4	0.012	0.144	0.146
Molybdenum	M	200	NC								

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c) Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c) Chronic Value	CWA AWQC for Protection of Human Health TBCs (c) Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c) Fish Consumption Only
Nickel	M	40	CT					1,400 (3)	160 (3)	13.4	100
Potassium	M	5000	CT								
Selenium	M	5	CT	10	50		50	20 (d)	5 (d)	10	
Silver	M	10	CT	50	100 *			4.1 (3)	0.12	50	
Sodium	M	5000	CT								
Strontium	M	200	NC								
Thallium	M	10	CT					1,400 (1)	40 (1)	13	48
Tin	M	200	NC								
Titanium	M	10	E6010								
Tungsten	M	10	E6010								
Vanadium	M	50	CT								
Zinc	M	20	CT	5,000 *				120 (3)	110 (3)		
2,4,5-TP Silvex	P		d	10	50		50				
2,4-Dichlorophenoxyacetic Acid (2,4-D)	P		d	100	70		70				
Aldicarb	P				3 (f)		1 (f)				
Aldrin	P	0.05	CP					3.0		0.000074	0.000079
Bromacil	P										
Carbofuran	P		d		40		40				
Chloranil											
Chlordane (Alpha)	P	0.5	CP		2		0	2.4	0.0043	0.00046	0.00048
Chlordane (Gamma)	P	0.5	CP		2		0	2.4	0.0043	0.00046	0.00048
Chlorpyrifos	P		E619					0.083	0.041		
DDT	P	0.1	CP					1.1	0.0011	0.000024	0.000024
DDT metabolite (DDD)	P	0.1	CP					0.06			
DDT metabolite (DDE)	P	0.1	CP					1,050			
Demeton	P								0.1		
Diazinon	P										
Dieldrin	P	0.1	CP					2.5	0.0019	0.00007	0.000076
Endosulfan I	P	0.05	CP					0.22	0.056	74	159
Endosulfan II	P	0.1	CP								
Endosulfan Sulfate	P	0.1	CP								
Endrin	P	0.1	CP	0.2				0.18	0.0023	1	
Endrin Ketone	P	0.1	CP								
Guthion	P								0.01		
Heptachlor	P	0.05	CP		0.4		0	0.52	0.0038	0.00028	0.00029
Heptachlor Epoxide	P	0.05	CP		0.2		0				
Hexachlorocyclohexane, Alpha	P	0.05	CP							0.0092	0.031
Hexachlorocyclohexane, Beta	P	0.05	CP							0.0163	0.0547
Hexachlorocyclohexane, Delta	P	0.05	CP								
Hexachlorocyclohexane, Technical	P		f							0.0123	0.0414
Hexachlorocyclohexane, (Lindane) Gama	P	0.05	CP	4	0.2		0.2	2.0	0.08		
Malathion	P								0.01		
Methoxychlor	P	0.5	CP	100	40		40		0.03	100	
Mirex	P								0.001		

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c)		CWA AWQC for Protection of Human Health TBCs (c)	
								Acute Value	Chronic Value	Water and Fish Ingestion	Fish Consumption Only
Parathion	P							0.065	0.013		
PCBs	P	0.5	CP		0.5		0	2.0	0.014	0.000079**	0.000079**
Simazine	P		e								
Toxaphene	P	1	CP		3		0	0.73	0.0002	0.00071**	0.00073**
Vaponite 2	P										
Aroclor 1016	PP	0.5	CP								
Aroclor 1221	PP	0.5	CP								
Aroclor 1232	PP	0.5	CP								
Aroclor 1242	PP	0.5	CP								
Aroclor 1248	PP	0.5	CP								
Aroclor 1254	PP	1	CP								
Aroclor 1260	PP	1	CP								
Atrazine	PP		e		3		3				
Americium (pCi/l)	R										
Americium 241 (pCi/l)	R	0.01									
Cesium 134 (pCi/l)	R	1									
Cesium 137 (pCi/l)	R	1									
Gross Alpha (pCi/l)	R	2		15 (10)							15
Gross Beta (pCi/l)	R	4		50 (4 mrem/yr)							
Plutonium (pCi/l)	R										
Plutonium 238+239+240 (pCi/l)	R	0.01									
Radium 226+228 (pCi/l)	R	0.5/0.1 (		5							5
Strontium 89+90 (pCi/l)	R	1									
Strontium 90 (pCi/l)	R			8 (6)							8
Thorium 230+232 (pCi/l)	R										
Tritium (pCi/l)	R			20,000 (6)							
Uranium 233+234 (pCi/l)	R										
Uranium 235 (pCi/l)	R	0.6									
Uranium 238 (pCi/l)	R	0.6									
Uranium (total) (pCi/l)	R										
1,2,4,5-Tetrachlorobenzene	SV		b							38	48
1,2,4-Trichlorobenzene	SV	10	CS								
1,2-Dichlorobenzene (Ortho)	SV	10	CS		600		600				
1,2-Diphenylhydrazine	SV		b					270 (1)			
1,3-Dichlorobenzene (Meta)	SV	10	CS								
1,4-Dichlorobenzene (Para)	SV	10	CS	75		75					
2,4,5-Trichlorophenol	SV	50	CS							2,600	
2,4,6-Trichlorophenol	SV	10	CS						970 (1)	1.2 **	3.6 **
2,4-Dichlorophenol	SV	10	CS					2,020 (1)	365 (1)	3,090	
2,4-Dimethylphenol	SV	10	CS					2,120 (1)			
2,4-Dinitrophenol	SV	50	CS								
2,4-Dinitrotoluene	SV	10	CS							0.11 **	9.1 **
2-Chloronaphthalene	SV	10	CS								

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c) Acute Value	Chronic Value	CWA AWQC for Protection of Human Health TBCs (c) Water and Fish Ingestion	Fish Consumption Only
2-Chlorophenol	SV	10	CS					4,360 (1)	2,000 (1)		
2-Methylnaphthalene	SV	10	CS								
2-Methylphenol	SV	10	CS								
2-Nitroaniline	SV	50	CS								
2-Nitrophenol	SV	10	CS								
3,3-Dichlorobenzidine	SV	20	CS							0.01	0.02
3-Nitroaniline	SV	50	CS								
4,6-Dinitro-2-methylphenol	SV	50	CS								
4-Bromophenyl Phenylether	SV	10	CS								
4-Chloroaniline	SV	10	CS								
4-Chlorophenyl Phenyl Ether	SV	10	CS								
4-Chloro-3-methylphenol	SV	10	CS					30 (1)			
4-Methylphenol	SV	10	CS								
4-Nitroaniline	SV	50	CS								
4-Nitrophenol	SV	50	CS					230 (1)	150 (1)		
Acenaphthene	SV	10	CS					1,700 (1)	520 (1)		
Anthracene	SV	10	CS								
Benzidine	SV		d					2,500		0.00012	0.00053
Benzoic Acid	SV	50	CS								
Benzo(a)anthracene	SV	10	CS								
Benzo(a)pyrene	SV	10	CS								
Benzo(b)fluoranthene	SV	10	CS								
Benzo(g,h,i)perylene	SV	10	CS								
Benzo(k)fluoranthene	SV	10	CS								
Benzyl Alcohol	SV	10	CS								
bis(2-Chloroethoxy)methane	SV	10	CS								
bis(2-Chloroethyl)ether	SV	10	CS							0.03**	1.36 **
bis(2-Chloroisopropyl)ether	SV	10	CS							34.7	4,360
bis(2-Ethylhexyl)phthalate	SV	10	CS							15,000	50,000
Butadiene	SV										
Butylbenzylphthalate	SV	10	CS								
Chlorinated Ethers	SV										
Chlorinated Napthalenes	SV							1,600 (1)			
Chloroalkylethers	SV	10	CS					238,000 (1)			
Chlorophenol	SV										
Chrysene	SV	10	CS								
Dibenzofuran	SV	10	CS								
Dibenz(a,h)anthracene	SV	10	CS								
Dichlorobenzenes	SV							1,120 (1)	763 (1)	400	2,600
Dichlorobenzidine	SV	20	CS							0.01	0.02
Diethylphthalate	SV	10	CS							350,000	1,800,000
Dimethylphthalate	SV	10	CS							313,000	2,900,000
Dinitrotoluene	SV	10	CS					330 (1)	230 (1)	70	14,300
Di-n-butylphthalate	SV	10	CS								
Di-n-octylphthalate	SV	10	CS								

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c): Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c): Chronic Value	CWA AWQC for Protection of Human Health TBCs (c): Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c): Fish Consumption Only
Ethylene Glycol	SV		d								
Fluoranthene	SV	10	CS					3,980 (1)		42	54
Fluorene	SV	10	CS								
Formaldehyde	SV										
Haloethers	SV							380 (1)	122 (1)		
Hexachlorobenzene	SV	10	CS							0.00072**	0.00074**
Hexachlorobutadiene	SV	10	CS					90 (1)	9.3 (1)	0.45**	50 **
Hexachlorocyclopentadiene	SV	10	CS					7 (1)	5.2 (1)	206	
Hexachloroethane	SV	10	CS					980 (1)	540 (1)	1.9	8.74
Hydrazine	SV										
Indeno(1,2,3-cd)pyrene	SV	10	CS								
Isophorone	SV	10	CS					117,000 (1)		5,200	520,000
Naphthalene	SV	10	CS					2,300 (1)	620 (1)		
Nitrobenzene	SV	10	CS					27,000 (1)		19,800	
Nitrophenols	SV							230 (1)	150 (1)		
Nitrosamines	SV							5,850 (1)			
Nitrosodibutylamine	SV		b							0.0064	0.587
Nitrosodiethylamine	SV		b							0.0008	1.24
Nitrosodimethylamine	SV		b							0.0014	16
Nitrosopyrrolidine	SV		b							0.016	91.9
N-Nitrosodiphenylamine	SV	10	b							4.9 **	16.1 **
N-Nitroso-di-n-dipropylamine	SV	10	b								
Pentachlorinated Ethanes	SV		b					7,240 (1)	1,100 (1)		
Pentachlorobenzene	SV		b							74	85
Pentachlorophenol	SV	50	CS		1 (f)		0 (f)	20 (4)	13 (4)	1,010	
Phenanthrene	SV	10	CS								
Phenol	SV	10	CS					10,200 (1)	2,560 (1)	3,500	
Phthalate Esters	SV		e					940 (1)	3 (1)		
Polynuclear Aromatic Hydrocarbons	SV		b							0.0028**	0.0311**
Vinyl Chloride	SV	10	CV	2		0				2 **	525 **
1,1,1-Trichloroethane	V	5	CV	200		200				18,400	1,030,000
1,1,2,2-Tetrachloroethane	V	5	CV						2,400	0.17**	10.7 **
1,1,2-Trichloroethane	V	5	CV						9,400	0.6**	41.8 **
1,1-Dichloroethane	V	5	CV								
1,1-Dichloroethene	V	5	CV	7		7					
1,2-Dichloroethane	V	5	CV	5		0		118,000	20,000	0.94**	243 **
1,2-Dichloroethene (cis)	V		a		70		70				
1,2-Dichloroethene (total)	V	5	CV								
1,2-Dichloroethene (trans)	V		a		100		100				
1,2-Dichloropropane	V	5	CV		5		0	23,000	5,700		
1,3-Dichloropropene (cis)	V	5	CV					6,060	244 (1)	87	14,100
1,3-Dichloropropene (trans)	V	5	CV					6,060	244 (1)	87	14,100
2-Butanone	V	10	CV								
2-Hexanone	V	10	CV								

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c): Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c): Chronic Value	CWA AWQC for Protection of Human Health TBCs (c): Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c): Fish Consumption Only
4-Methyl-2-pentanone	V	10	CV								
Acetone	V	10	CV								
Acrylonitrile	V		c					7,500	2,600	0.058	0.65
Benzene	V	5	CV	5		0		5,300		0.66**	40 **
Bromodichloromethane	V	5	CV								
Bromoform	V	5	CV								
Bromomethane	V	10	CV								
Carbon Disulfide	V	5	CV								
Carbon Tetrachloride	V	5	CV	5		0		35,200 (1)		0.4**	6.94 **
Chlorinated Benzenes	V	10	CV/CS					250 (1)	50 (1)		
Chlorobenzene	V	5	CV/CS		100		100				
Chloroethane	V	10	CV								
Chloroform	V	5	CV	Tot THM<100 (2)				28,900 (1)	1,240 (4)	0.19 **	15.7 **
Chloromethane	V	10	CV								
Dibromochloromethane	V	5	CV								
Dichloroethenes	V							11,600 (1)		0.033**	1.85 **
Ethyl Benzene	V	5	CV		700		700	32,000 (1)		1,400	3,280
Ethylene Dibromide	V		d		0.05		0				
Ethylene Oxide	V										
Halomethanes	V			100				11,000 (1)		0.19**	15.7 **
Methylene Chloride	V	5	CV								
Pyrene	V	10	CS								
Styrene	V	5	CV		100		100				
Tetrachloroethanes	V	5	CV					9,320 (1)			
Tetrachloroethene	V	5	CV		5		0	5,280 (1)	840 (1)	0.80**	8.85 **
Toluene	V	5	CV		1,000		1,000	17,500 (1)		14,300	424,000
Trichloroethanes	V	5	CV					18,000 (1)			
Trichloroethene	V	5	CV	5		0		45,000 (1)	21,900 (1)	2.7 **	80.7 **
Vinyl Acetate	V	10	CV								
Xylenes (total)	V	5	CV		10,000		10,000				

EXPLANATION OF TABLE

* = secondary maximum contaminant level, TBCs
** = Human health criteria for carcinogens reported for three risk levels. Value presented is the 10-5 risk level.

AWQC	= Ambient Water Quality Criteria
CLP	= Contract Laboratory Program
CWA	= Clean Water Act
EPA	= Environmental Protection Agency
pCi/l	= picocuries per liter
PCB	= polychlorinated biphenyl
PQL	= Practical Quantitation Level
SDWA	= Safe Drinking Water Act
SS	= Species Specific

TABLE 3-2
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
FEDERAL SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (7)	PQL MDL	Method (8)	SDWA Maximum Contaminant Level (a)	SDWA Maximum Contaminant Level TBCs (b)	SDWA Maximum Contaminant Level Goals TBCs (a)	SDWA Maximum Contaminant Level Goals TBCs (b)	CWA AWQC for Protection of Aquatic Life TBCs (c): Acute Value	CWA AWQC for Protection of Aquatic Life TBCs (c): Chronic Value	CWA AWQC for Protection of Human Health TBCs (c): Water and Fish Ingestion	CWA AWQC for Protection of Human Health TBCs (c): Fish Consumption Only

TAL = Target Analyte List
THM = Total Trihalomethanes
TIC = Tentatively Identified Compound
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis

(1) criteria not developed; value presented is lowest observed effects level (LOEL)
(2) total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane
(3) hardness dependent criteria
(4) pH dependent criteria (7.8 pH used)
(5) standard is not adequately protective when chloride is associated with potassium, calcium, or magnesium, rather than sodium.
(6) if both strontium-90 and tritium are present, the sum of their annual dose equivalents to bone marrow shall not exceed 4 mrem/yr.
(7) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; FP=field parameter; I=indicator; M=metal; P=Pesticide; PP=Pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile
(8) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TIC in CS; c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.
(9) MDL for radium 226 is 0.5; MDL for radium 228 is 1.0
(10) Value for gross alpha excludes uranium

(a) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR 141 and 40 CFR 143 (as of May 1990). Segment 4 MCLs are ARAR; Segment 5 MCLs are TBC; all MCLGs are TBC.
(b) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142 and 143, Final Rule (56 FR 3526; 1/30/91) effective July 30, 1992.
(c) EPA, Quality Criteria for Protection of Aquatic Life, 1986
(d) EPA, National Ambient Water Quality Criteria for Selenium - 1987
(e) EPA, National Ambient Water Quality Criteria for Chloride - 1988
(f) EPA National Primary and Secondary Drinking Water Regulations, 40 CFR Parts 141, 142, and 143, Final Rule (56 FR 30266; 7/1/1991) effective 1/1/1993.
(g) EPA Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper, 40 CFR 141 and 142 (56 FR 26460; 6/7/1991) effective 11/6/1991.

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
Bicarbonate	A	10	E310.1																
Carbonate	A	10	E310.1																
Chloride	A	5	E325							250,000						3	3		
Chlorine	A	1000	E4500				3	3								3	3		
Fluoride	A	5	E340							2,000									
N as Nitrate	A	5	E353.1						100,000	10,000						10,000	10,000		
N as Nitrate+Nitrite	A	5	E353.1						100,000	10,000									
N as Nitrite	A	5	E354.1				SS	SS	10,000	1,000						1,000	1,000		
Sulfate	A	5	E375.4							250,000						250,000	250,000		
Sulfide	A							2		50									
Coliform (Fecal)	B	1	SM9221C							2000/100									
Ammonia as N	C	5	E350				620	60		500						620	60		
Dioxin	D		d	0.00000022 (13)	0.01	0.00001							0.00000 (13)	0.00000001			0.000000013		
Sulfur	E	100,000	E600													2.0	2.0		
Dissolved Oxygen	FP	0.5	SM4500				5,000	5,000	3,000	3,000						5,000	5,000		
pH	FP	0.1	E150.1				6.5-9.0	6.5-9.0		5.0-9.0						6.5-9	6.5-9		
Specific Conductance	FP	1	E120.1																
Temperature	FP						30 degrees	30 degrees											
Boron	I	5	E6010						750							750	750		
Total Dissolved Solids	I	10	E160.1																
Aluminum	M	200	CT				950	150											
Antimony	M	60	CT																
Arsenic	M	10	CT				360	150	100	50						50			
Arsenic III	M																		
Arsenic V	M																		
Barium	M	200	CT							1,000									
Beryllium	M	5	CT						100										
Cadmium	M	5	CT				TVS	TVS	10	10						TVS	TVS		
Calcium	M	5,000	CT																
Cesium	M	1,000	NC																
Chromium	M	10	CT																
Chromium III	M	5	SW8467196				TVS	TVS	100	50						TVS	TVS		
Chromium VI	M	10	E218.5				16	11	100	50						16	62		
Cobalt	M	50	CT																
Copper	M	25	CT				TVS	TVS	200	1,000						TVS	TVS		
Cyanide	M	10	CT				5	5	200	200						5	5		
Iron	M	100	CT					1,000		300 (dis)							300 (5)		
Lead	M	5	CT				TVS	TVS	100	50						TVS	TVS		
Lithium	M	100	NC																
Magnesium	M	5000	CT																

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a): Tables A,B Carcinogens/ Noncarcinogens (2)	Statewide Standards (a): Table C Aquatic Life: Acute Value	Statewide Standards (a): Table C Aquatic Life: Chronic Value	Statewide Standards (a): Tables I,II,III (1) Aquatic Life: Acute Value (2)	Statewide Standards (a): Tables I,II,III (1) Aquatic Life: Chronic Value (2)	Statewide Standards (a): Tables I,II,III (1): Agricultural Standard (3)	Statewide Standards (a): Tables I,II,III (1): Domestic Water Supply (6)	Basin Standards (b): Organics (12) Aquatic Life	Basin Standards (b): Water Supply	Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7): Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio-nuclide	Stream Segment Table (8): Acute Value	Stream Segment Table (8): Chronic Value	Table 2 Radionuclides: Woman Creek	Table 2 Radionuclides: Walnut Creek
Manganese	M	15	CT					1,000	200	50 (dis)							50 (5)		
Mercury	M	0.2	CT				2.4	0.1		2.0							0.1		
Molybdenum	M	200	NC																
Nickel	M	40	CT				TVS	TVS	200							TVS	TVS		
Potassium	M	5000	CT																
Selenium	M	5	CT				135	17	20	10						10			
Silver	M	10	CT				TVS	TVS		50						TVS	TVS		
Sodium	M	5000	CT																
Strontium	M	200	NC																
Thallium	M	10	CT					15											
Tin	M	200	NC																
Titanium	M	10	E6010																
Tungsten	M	10	E6010																
Vanadium	M	50	CT																
Zinc	M	20	CT				TVS	TVS	2,000	5,000						TVS	TVS		
2,4,5-TP Silvex	P		d	10									10						
2,4-D	P		d	100								100	100						
Aldicarb	P			10									10						
Aldrin	P	0.05	CP	0.002 (13)	3						0.003		0.002 (1	0.000074			0.000074		
Bromacil	P																		
Carbofuran	P		d	36									36						
Chloranil	P		E619																
Chlordane (Alpha)	P	0.5	CP	0.03 (13)	2.4	0.0043							0.03 (13	0.00046			0.00046		
Chlordane (Gamma)	P	0.5	CP	0.03 (13)	2.4	0.0043							0.03 (13	0.00046			0.00046		
Chlorpyrifos	P				0.083	0.041													
DDT	P	0.1	CP	0.1 (13)	1.1	0.001					0.001		0.1 (13)	0.000024			0.000024		
DDT Metabolite (DDD)	P	0.1	CP		0.6						0.001								
DDT Metabolite (DDE)	P	0.1	CP		1,050						0.001								
Demeton	P					0.1					0.1								
Diazinon	P																		
Dieldrin	P	0.1	CP	0.002 (13)	2.5	0.0019					0.003		0.002 (1	0.000071			0.000071		
Endosulfan I	P	0.05	CP		0.22	0.056					0.003								
Endosulfan II	P	0.1	CP																
Endosulfan Sulfate	P	0.1	CP																
Endrin	P	0.1	CP	0.2	0.18	0.0023					0.004		0.2						
Endrin Ketone	P	0.1	CP																
Guthion	P					0.01					0.01								
Heptachlor	P	0.05	CP	0.008 (13)	0.52	0.0038					0.001	0.2	0.008 (1	0.00028			0.00028		
Heptachlor Epoxide	P	0.05	CP	0.004 (13)									0.004 (1						

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a): Tables A,B Carcinogens/Noncarcinogens (2)	Statewide Standards (a): Table C Aquatic Life Acute Value	Statewide Standards (a): Table C Aquatic Life Chronic Value	Statewide Standards (a): Tables I,II,III (1) Aquatic Life Acute Value (2)	Statewide Standards (a): Tables I,II,III (1) Aquatic Life Chronic Value (2)	Statewide Standards (a): Tables I,II,III (1) Agricultural Standard (3)	Statewide Standards (a): Tables I,II,III (1) Domestic Water Supply (6)	Basin Standards (b): Organics (12) Aquatic Life	Basin Standards (b): Water Supply	Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7): Tables A,B (2)	Segment 4 & 5: Table C Fish & Water Ingestion	Segment 4 & 5: Table D Radionuclide	Segment 4 & 5: Stream Segment Table (8) Acute Value	Segment 4 & 5: Stream Segment Table (8) Chronic Value	Segment 4 & 5: Table 2 Radionuclides Woman Creek	Segment 4 & 5: Table 2 Radionuclides Walnut Creek
Hexachlorocyclohexane Alpha	P	0.05	CP											0.0092			0.0092		
Hexachlorocyclohexane Beta	P	0.05	CP											0.0163			0.0163		
Hexachlorocyclohexane Delta	P	0.05	CP																
Hexachlorocyclohexane Tech.	P		f											0.0123			0.0123		
Hexachlorocyclohexane Lindane	P	0.05	CP	4	2.0	0.08					0.1	4.0	4	0.0186			0.0186		
Malathion	P					0.1					0.1								
Methoxychlor	P	0.5	CP	100		0.03					0.03	100	100						
Mirex	P					0.008					0.001								
Parathion	P				0.065	0.013					0.04								
PCBs	P	0.5	CP	0.005 (13)	2.0	0.014					0.001		0.005 (1	0.000079			0.000079		
Simazine	P		e														4		
Toxaphene	P	1	CP	5	0.73	0.0002					0.005	5.0	5						
Vaponite 2	P																		
Aroclor 1016	PP	0.5	CP																
Aroclor 1221	PP	0.5	CP																
Aroclor 1232	PP	0.5	CP																
Aroclor 1242	PP	0.5	CP																
Aroclor 1248	PP	0.5	CP																
Aroclor 1254	PP	1	CP																
Aroclor 1260	PP	1	CP																
Atrazine	PP		e														3		
Americium (pCi/l)	R																	0.05	0.05
Americium 241 (pCi/l)	R	0.01													30				
Cesium 134 (pCi/l)	R	1		80 (6)											80				
Cesium 137 (pCi/l)	R	1																	
Gross Alpha (pCi/l)	R	2																7	11
Gross Beta (pCi/l)	R	4																5	19
Plutonium (pCi/l)	R																	0.05	0.05
Plutonium 238+239+240	R	0.01		15 (6)											15				
Radium 226+228 (pCi/l)	R	0.5/1.0 (14		5 (6)											5				
Strontium 89+90 (pCi/l)	R	1																	
Strontium 90 (pCi/l)	R			8 (6)											8				
Thorium 230+232 (pCi/l)	R			60 (6)											60				
Tritium (pCi/l)	R			20,000 (6)											20,000			500	500
Uranium 233+234 (pCi/l)	R																		
Uranium 235 (pCi/l)	R	0.6																	
Uranium 238 (pCi/l)	R	0.6																	

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life				Organics (12)		Tables	Table C	Table D	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)	Carcinogens/ Noncarcinogens (2)	Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply	A,B (2)	Fish & Water Ingestion	Radio-nuclide	Acute Value	Chronic Value	Woman Creek	Walnut Creek
Uranium (Total) (pCi/l)	R						TVS	TVS							40			5	10
1,2,4,5-Tetrachlorobenzen	SV		b	2 (13)									2						
1,2,4-Trichlorobenzene	SV	10	CS																
1,2-Dichlorobenzene (Orth	SV	10	CS	620									620						
1,2-Diphenylhydrazine	SV		b	0.05 (13)									0.05 (13						
1,3-Dichlorobenzene (Met	SV	10	CS	620									620						
1,4-Dichlorobenzene (Para	SV	10	CS	75									75						
2,4,5-Trichlorophenol	SV	50	CS	700									700						
2,4,6-Trichlorophenol	SV	10	CS	2.0 (13)		970							2.0 (13)	1.2			1.2		
2,4-Dichlorophenol	SV	10	CS	21	2,020	365							21						
2,4-Dimethylphenol	SV	10	CS		2,120														
2,4-Dinitrophenol	SV	50	CS																
2,4-Dinitrotoluene	SV	10	CS																
2-Chloronaphthalene	SV	10	CS																
2-Chlorophenol	SV	10	CS		4,380	2,000													
2-Methylnaphthalene	SV	10	CS																
2-Methylphenol	SV	10	CS																
2-Nitroaniline	SV	50	CS																
2-Nitrophenol	SV	10	CS																
3,3-Dichlorobenzidine	SV	20	CS											0.01			0.01		
3-Nitroaniline	SV	50	CS																
4,6-Dinitro-2-methylphenol	SV	50	CS																
4-Bromophenyl Phenyleth	SV	10	CS																
4-Chloroaniline	SV	10	CS																
4-Chlorophenyl Phenyl Et	SV	10	CS																
4-Chloro-3-methylphenol	SV	10	CS		30														
4-Methylphenol	SV	10	CS																
4-Nitroaniline	SV	50	CS																
4-Nitrophenol	SV	50	CS																
Acenaphthene	SV	10	CS		1,700	520													
Anthracene	SV	10	CS																
Benzidine	SV		d	0.0002 (13)	2,500						0.1	0.01	0.0002 (	0.00012			0.00012		
Benzoic Acid	SV	50	CS																
Benzo(a)anthracene	SV	10	CS																
Benzo(a)pyrene	SV	10	CS																
Benzo(b)fluoranthene	SV	10	CS																
Benzo(g,h,i)perylene	SV	10	CS																
Benzo(k)fluoranthene	SV	10	CS																
Benzyl Alcohol	SV	10	CS																
bis(2-Chloroethoxy)metha	SV	10	CS																
bis(2-Chloroethyl)ether	SV	10	CS	0.03 (13)									0.03 (13	0.0000037			0.0000037		
bis(2-Chloroisopropyl)ethe	SV	10	CS																

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (2)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life		Agricultural Standard (3)	Domestic Water Supply (6)	Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)			Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
bis(2-Ethylhexyl)phthalate	SV	10	CS																
Butadiene	SV																		
Butyl Benzylphthalate	SV	10	CS																
Chlorinated Ethers	SV																		
Chlorinated Napthalenes	SV																		
Chloroalkylethers	SV	10	CS																
Chlorophenol	SV										1.0	1.0							
Chrysene	SV	10	CS																
Dibenzofuran	SV	10	CS																
Dibenz(a,h)anthracene	SV	10	CS																
Dichlorobenzenes	SV																		
Dichlorobenzidine	SV	20	CS											0.01			0.01		
Diethylphthalate	SV	10	CS																
Dimethylphthalate	SV	10	CS																
Dinitrotoluene	SV	10	CS		330	230													
Di-n-butylphthalate	SV	10	CS																
Di-n-octylphthalate	SV	10	CS																
Ethylene Glycol	SV		d																
Fluoranthene	SV	10	CS		3,980														
Fluorene	SV	10	CS																
Formaldehyde	SV																		
Haloethers	SV																		
Hexachlorobenzene	SV	10	CS	0.02 (13)									0.02 (13	0.00072			0.00072		
Hexachlorobutadiene	SV	10	CS	14	90	9.3							14	0.45			0.45		
Hexachlorocyclopentadien	SV	10	CS	49	7	5.2							49						
Hexachloroethane	SV	10	CS		980	540								1.9			1.9		
Hydrazine	SV																		
Indeno(1,2,3-cd)pyrene	SV	10	CS																
Isophorone	SV	10	CS	1,050	117,000								1,050						
Naphthalene	SV	10	CS		2,300	620													
Nitrobenzene	SV	10	CS	3.5 (13)	27,000								3.5 (13)						
Nitrophenols	SV																		
Nitrosamines	SV																		
Nitrosodibutylamine	SV		b											0.0064			0.0064		
Nitrosodiethylamine	SV		b											0.0008			0.0008		
Nitrosodimethylamine	SV		b											0.0014			0.0014		
Nitrosopyrrolidine	SV		b											0.016			0.016		
N-Nitrosodiphenylamine	SV	10	CSb											4.9			4.9		
N-Nitroso-di-n-dipropylam	SV	10	CSb																
Pentachlorinated Ethanes	SV		b																
Pentachlorobenzene	SV		b	6 (13)									6 (13)						
Pentachlorophenol	SV	50	CS	200	9	5.7							200						
Phenanthrene	SV	10	CS																

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

Parameter	Type (10)	PQL MDL	Method (11)	Statewide Standards (a): Tables A,B Carcinogens/ Noncarcinogens (8)	Statewide Standards (a): Table C Aquatic Life: Acute Value	Statewide Standards (a): Table C Aquatic Life: Chronic Value	Statewide Standards (a): Tables I,II,III (1) Aquatic Life: Acute Value (2)	Statewide Standards (a): Tables I,II,III (1) Aquatic Life: Chronic Value (2)	Statewide Standards (a): Agricultural Standard (3)	Statewide Standards (a): Domestic Water Supply (8)	Basin Standards (b): Organics (12) Aquatic Life	Basin Standards (b): Water Supply	Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7): Tables A,B (2)	Segment 4 & 5: Table C Fish & Water Ingestion	Segment 4 & 5: Table D Radio-nuclide	Segment 4 & 5: Stream Segment Table (6): Acute Value	Segment 4 & 5: Stream Segment Table (6): Chronic Value	Segment 4 & 5: Table 2 Radionuclides: Woman Creek	Segment 4 & 5: Table 2 Radionuclides: Walnut Creek
Phenol	SV	10	CS		10,200	2,560					500	1.0							
Phthalate Esters	SV		e																
Polynuclear Aromatic Hyd	SV		b											0.0028			0.0028		
Vinyl Chloride	SV	10	CV	2									2						
1,1,1-Trichloroethane	V	5	CV	200									200						
1,1,2,2-Tetrachloroethane	V	5	CV			2,400								0.17			0.17		
1,1,2-Trichloroethane	V	5	CV	28		9,400							28	0.60			0.60		
1,1-Dichloroethane	V	5	CV																
1,1-Dichloroethene	V	5	CV	7									7						
1,2-Dichloroethane	V	5	CV	5	118,000	20,000							5						
1,2-Dichloroethene (cis)	V		a	70									70						
1,2-Dichloroethene (total)	V	5	CV																
1,2-Dichloroethene (trans)	V		a	70									70						
1,2-Dichloropropane	V	5	CV	0.56 (13)	23,000	5,700							0.56 (13						
1,3-Dichloropropene (cis)	V	5	CV		6,060	244													
1,3-Dichloropropene (tran	V	5	CV		6,060	244													
2-Butanone	V	10	CV																
2-Hexanone	V	10	CV																
4-Methyl-2-pentanone	V	10	CV																
Acetone	V	10	CV																
Acrylonitrile	V		c		7,550	2,600								0.058			0.058		
Benzene	V	5	CV	5	5,300								5						
Bromodichloromethane	V	5	CV																
Bromoform	V	5	CV																
Bromomethane	V	10	CV																
Carbon Disulfide	V	5	CV																
Carbon Tetrachloride	V	5	CV	5	35,200								5						
Chlorinated Benzenes	V	10	CV/CS																
Chlorobenzene	V	5	CV/CVS	300									300						
Chloroethane	V	10	CV																
Chloroform	V	5	CV	Tot THM <100 (4)	28,900	1,240							Tot THM <100 (4	0.19			0.19		
Chloromethane	V	10	CV																
Dibromochloromethane	V	5	CV																
Dichloroethenes	V																		
Ethyl Benzene	V	5	CV	680	32,000								680						
Ethylene Dibromide	V		d																
Ethylene Oxide	V																		
Halomethanes	V			100									100	0.19			0.19		
Methylene Chloride	V	5	CV																
Pyrene	V	10	CS																
Styrene	V	5	CV																

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/ Noncarcinogens (5)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radio-nuclide	Stream Segment Table (6)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricul-tural Standard (3)	Domestic Water Supply (8)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek
Tetrachloroethanes	V	5	CV																
Tetrachloroethene	V	5	CV	10	5,280	840							10	0.8			0.8		
Toluene	V	5	CV	2,420	17,500								2,420						
Trichloroethanes	V	5	CV																
Trichloroethene	V	5	CV	5	45,000	21,800							5						
Vinyl Acetate	V	10	CV																
Xylenes (Total)	V	5	CV																

EXPLANATION OF TABLE

CLP = Contract Laboratory Program
CDH = Colorado Department of Health
dis = dissolved
EPA = Environmental Protection Agency
pCi/l = picocuries per liter
PCB = polychlorinated biphenyl
PQL = Practical Quantitation Level
SS = species specific
TAL = Target Analyte List
THM = Total Trihalomethanes
TIC = Tentatively Identified Compound
TVS = Table Value Standard (hardness dependent), see Table III in (a)
MDL = Minimum Detection Limit for radionuclides (pCi/l)
ug/l = micrograms per liter
VOA = Volatile Organic Analysis
WQCC = Water Quality Control Commission

(1) Table I = physical and biological parameters
Table II = inorganic parameters
Table III = metal parameters
Values in Tables I, II, and III for recreational uses, cold water biota and domestic water supply are not included.
(2) In the absence of specific, numeric standards for non-naturally occurring organics, the narrative standard is interpreted as zero with enforcement based on practical quantification levels (PQLs) as defined by CDH/WQCC or EPA
(3) All are 30-day standards except for nitrate+nitrite
(4) Total trihalomethanes: chloroform, bromoform, bromodichloromethane, dibromochloromethane
(5) Lowest value given: dissolved or total recoverable
(6) Ammonia, sulfide, chloride, sulfate, copper, iron, manganese, and zinc are 30-day standards, all others are 1-day standards
(7) Segment 5 standards are goals
(8) Includes Table 1: Additional Organic Chemical Standards (chronic only)
(9) See section 3.1.11 (I)(2) in (a)
(10) type abbreviations are: A=anion; B=bacteria; C=cation; D=dioxin; FP=field parameter; I=indicator; M=metal; P= pesticide; PP=pesticide/PCB; R=radionuclide; SV=semi-volatile; V=volatile
(11) method abbreviations are: CT=CLP-TAL; NC=non-CLP; CV=CLP-VOA; CS=CLP-SEMI; EP=EPA-PEST; CP=CLP-PEST; E=EPA; a = detected as total in CV; b = detected as TICs in CS; c = detected as TIC in CV; d = not routinely monitored; e = monitored in discharge ponds; f = mixture-individual isomers detected.

TABLE 3-3
POTENTIAL CHEMICAL-SPECIFIC ARARs/TBCs (October 1, 1991)
STATE (CDH/CWQCC) SURFACE WATER QUALITY STANDARDS (ug/l)

				Statewide Standards (a)							Basin Standards (b)		Segment 4 & 5 Stream Classification and Water Quality Standards (b)(7)						
				Tables A,B Carcinogens/Noncarcinogens (5)	Table C Aquatic Life		Tables I,II,III (1) Aquatic Life				Organics (12)		Tables A,B (2)	Table C Fish & Water Ingestion	Table D Radionuclide	Stream Segment Table (8)		Table 2 Radionuclides	
Parameter	Type (10)	PQL MDL	Method (11)		Acute Value	Chronic Value	Acute Value (2)	Chronic Value (2)	Agricultural Standard (3)	Domestic Water Supply (6)	Aquatic Life	Water Supply				Acute Value	Chronic Value	Woman Creek	Walnut Creek

(12) See Section 3.6.5 (2)(a) in (b)
(13) Standard is below (more stringent than) PQL, therefore PQL is standard.
(14) MDL for Radium 226 is 0.5; MDL for Radium 228 is 1.0

(a) CDH/WQCC, Colorado Water Quality Standards 3.1.0 (5 CCR 1002-8) 1/15/1974; amended 9/30/1989 (ARAR)
(Envrionmental Reporter 726:1001-1020:8/1990)
(b) CDH/WQCC, Classifications and Numeric Standards for S. Platte River Basin, Laramie River Basin, Republican River Basin, Smoky Hill River Basin 3.8.0 (5 CCR 1002-8) 4/8/1981; amended 2/15/1990.
Basin-wide standards are ARAR; Site-specific standards are TBC.

4.0 DATA NEEDS AND DATA QUALITY OBJECTIVES

Phase I RFI/RI Data Quality Objectives (DQOs) have been developed for the collection of field data to supplement the existing, historical data which have been evaluated in Section 2.0 of this Work Plan. The field sampling and analysis program, which is detailed in Section 7.0 of this Work Plan, will augment the available data by generating new information from untested areas within the site boundaries to achieve more uniform coverage of sampling. The program will also generate new types of information with consistent, standardized quality assurance objectives and procedures which increase validity, and establish relative levels of confidence for individual data and the resulting interpretations.

Portions of the historical data set for the West Spray Field are of uncertain quality, and apparent discrepancies prevent accurate, meaningful analysis. The proposed field sampling and analysis program will generate a comprehensive set of field observations, field measurements, and laboratory data types. The proposed use of each type of information will dictate the level of data quality required for that measurement.

Site-specific data requirements and related DQOs are summarized in Table 4-1. The data collection activities will focus on characterization of the site physical features and the nature of contamination from the source(s) and soils, as required of the Phase I RFI/RI by the IAG. Definition of site physical features and contamination sources will include: a surface radiation survey; surficial soil sampling task, and a subsurface soil sampling task from test pits. The primary objective of an RFI/RI is collection of data necessary to evaluate the nature, distribution, and migration pathways of contaminants, and to quantify any risks to human health and the environment. These assessments will determine the need for remediation and will be used to evaluate remedial alternatives, if necessary. The five general goals of an RFI/RI (U.S. EPA, 1988a) are as follows:

1. Characterize site physical features;
2. Define contaminant sources;
3. Determine the nature and extent of contamination;
4. Describe contaminant fate and transport; and
5. Provide a baseline risk assessment.

However, in accordance with the IAG, the RFI/RI for OU 11 has been divided into two phases. Phase I of the RFI/RI will address characterization of the site physical features, nature, extent, fate and transport of contaminant sources and a Baseline Risk Assessment within the West Spray Field. The nature, extent, fate and transport of contamination in groundwater will be investigated as part of the Phase II RFI/RI. The air pathway for contaminant migration will also be investigated as part of the Phase II RFI/RI.

DQOs are qualitative and quantitative statements that specify the quality and quantity of data required to support the objectives of the RFI/RI (U.S. EPA, 1987). The DQO process is divided into three stages:

Stage 1 - Identify decision types;
Stage 2 - Identify data uses/needs; and
Stage 3 - Design data collection program.

Through application of the DQO process, site-specific goals were established for the Phase I RFI/RI and data needs were identified for achieving those goals. This section of the RFI/RI Work Plan discusses the DQO process specific to the Phase I RFI/RI for OU 11.

Data collected during previous investigations have been useful in developing and focusing the DQOs. Previous data collection activities focused on site characterization rather than performing a quantitative risk assessment or environmental evaluation. The historical data, along with the OU 11 conceptual model, were summarized in Section 2.0 of this Work Plan. This section presents the rationale used in identifying OU 11 data needs.

4.1 STAGE 1 - IDENTIFY DECISION TYPES

Stage 1 of the DQO process identifies the decision makers, data users, and the types of decisions made as part of the RFI/RI process. The information is then used to identify the data needs and objectives. The following paragraphs discuss in more detail the identification of data users, development of the conceptual model and the resulting data objectives and decisions for OU 11.

4.1.1 Identify and Involve Data Users

Data users are divided into three groups: decision makers, primary data users, and secondary data users. The decision makers for OU 11 are personnel from EG&G, DOE, EPA, and CDH. These personnel are responsible for decisions related to management, regulation, investigation, and remediation of OU 11. The decision makers are involved through the review and approval process specified in the IAG. Primary data users are individuals involved in ongoing Phase I RFI/RI activities for OU 11. These individuals are the technical staff of CDH, EPA, DOE, EG&G, and EG&G subcontractors. Primary data users include geoscientists, statisticians, risk assessors, engineers, and health and safety personnel. The primary data users will be involved in collection and analysis of data and in preparation of the Phase I RFI/RI report, including the Baseline Human Health Risk Assessment and the Environmental Evaluation. Secondary data users are those users who rely on RFI/RI outputs to support their activities. Secondary data users of the Phase I RFI/RI information may include personnel from EPA, CDH, DOE, EG&G, and EG&G subcontractors working in areas such as data base management, quality assurance, records control, and laboratory management.

4.1.2 Evaluation of Available Data

The historical investigations conducted at the West Spray Field and associated areas of OU 11 have generated data which were evaluated for completeness and used in identifying current data gaps. The previously collected data is described in Section 2.0 of this Work Plan. The following is a brief discussion of the completeness and usability of existing data based on the information presented in Section 2.0.

4.1.2.1 Quality and Usability of Analytical Data

Historical analytical data from 1988 to present, which was used in characterizing contamination at OU 11 has been validated in accordance with the Rocky Flats EM Program Quality Assurance (QA) procedures. Data has been labeled as valid or rejected depending on whether or not it meets criteria established in the EM program. The data from the 1986 soil sampling for OU 11 were rejected because (1) sampling/analytical protocol did not conform to significant aspects of the QA/QC Plan (Rockwell International, 1989) or (2) there was insufficient documentation to demonstrate conformance with these procedures. Rejected data can be considered qualitative measures of the analyte concentrations. Analytical data generated under the RCRA annual groundwater monitoring program for the West Spray Field were considered valid from 1988 to present.

The historical analytical data were used qualitatively and quantitatively to scope the RFI/RI activities at OU 11 as presented in this Work Plan. However, additional inorganic, volatile organic and radionuclide data are needed to accurately evaluate contamination at OU 11. The usability of groundwater data collected quarterly under the RCRA and Colorado Hazardous

Waste Act (CHWA) groundwater monitoring requirements for regulated units, will be evaluated during development of the Phase II RFI/RI Work Plan.

4.1.2.2 Physical Setting

The physical setting of the West Spray Field area is described in detail in Section 2.0. Additional data are needed to characterize the hydrogeologic conditions of the site for development of the site conceptual model. Specific information regarding the vadose zone is required for evaluating contaminant fate and transportation.

4.1.2.3 Characterization of Contamination of the West Spray Field

The nature of contamination is described in detail in Section 2.3. Previous investigations characterized the groundwater, soils and subsurface soils in the vadose zone underlying the West Spray Field through limited surface and test pit sampling, borehole drilling and monitoring well installations. Additional work is required to better define the contaminant sources, and nature of the potential pathways for contaminant exposure to human and biotic receptors. Contamination in the groundwater and air pathways will be investigated in the Phase II RFI/RI as required by the IAG.

4.1.3 Develop Conceptual Model

A conceptual model for OU 11 has been developed in Section 2.4 and is illustrated in Figure 2-10. This model includes a description of contaminant sources, release mechanisms, transport medium, contaminant migration pathways, exposure routes, and receptors. The site-specific conceptual model for OU 11 is discussed briefly below.

The primary potential sources of contamination at the West Spray Field are the surface soil and sediment. During operation of the West Spray Field, surface runoff was also a primary source of contamination within and outside of OU 11. Secondary sources of contamination are the subsurface soils within the vadose and saturated zones and groundwater as a result of infiltration and percolation of ponding surface water. The Phase II RFI/RI process will determine if the alluvial and bedrock aquifers have been impacted by the activities conducted during operation of the West Spray Field.

The primary release mechanisms for contaminants from the West Spray Field are fugitive dust, surface water runoff, infiltration/percolation, bioconcentration/bioaccumulation and tracking. The exposure pathways for contaminants from the West Spray Field to reach receptors are via ingestion, inhalation, or dermal contact to windblown contaminated soil, contaminated groundwater, and contaminated surface water. Receptors are defined as the human or ecological populations exposed to contaminants at the exposure points.

4.1.4 Specify Phase I RFI/RI Objectives and Data Needs

Based on the existing site information (Sections 2.1 and 2.2), the nature of contamination (Section 2.3), the site-specific conceptual model for OU 11 (Section 2.4), and an evaluation of the quality and usability of the existing data (Section 4.1.2), site-specific Phase I RFI/RI objectives/data needs associated with identifying and characterizing contaminant sources have been developed. These are summarized in Table 4-1 and are discussed below.

In accordance with the IAG, the specific objectives of the Phase I RFI/RI field investigation for OU 11 are as follows:

Characterize Site Physical Features

- Verify the boundaries of the West Spray Field;
- Determine the past location(s) of the spray irrigation lines;
- Identify potential caliche zones in surficial deposits;
- Determine permeability of subsurface materials; and
- Delineate the areas of historic surface water runoff.

Define Contaminant Sources

- Determine the representative site-specific background concentrations of analytes in surface and subsurface soils;
- Determine the presence or absence of contamination in surficial soils;
- Determine the presence or absence of contamination in the vadose zone;
- Determine the presence or absence of contamination in sediment from surface-water runoff within the West Spray Field; and
- Determine the human and biotic receptors potentially impacted by contamination within the boundaries of the West Spray Field.

Provide a Baseline Risk Assessment

The objectives of the Baseline Risk Assessment are discussed in Sections 8.0.

Provide an Environmental Evaluation

The objectives of the Environmental Evaluation are discussed in Section 9.0.

Determine Nature and Extent of Contamination

The nature and extent of the contamination at the sources will be determined through evaluation of surface soil, subsurface material, and sediment samples. The nature and extent of contamination outside the boundaries of the West Spray Field will be addressed in the Phase II RFI/RI Work Plan.

Determine Contaminant Fate and Transport

In the Phase I RFI/RI, the fate and transport of contaminants within the West Spray Field boundaries will be addressed by evaluating the movement of key contaminant parameters within the vadose zone underlying the boundaries of the West Spray Field. The Phase II RFI/RI may utilize surface and groundwater modeling to predict movement and ultimate deposition of contaminants in the subsurface and surficial environments as well as the fate and transport of contaminants outside the West Spray Field boundaries.

4.2 STAGE 2 - IDENTIFY DATA USES/NEEDS

The data needed to meet each of the site-specific Phase I RFI/RI objectives developed for OU 11 are listed in Table 4-1. The associated sampling and analysis activities are also identified in Table 4-1. Specific plans for obtaining the needed data are presented in Section 7.0 (Field Sampling Plan). The following sections discuss the uses, general types, quality, and quantity of the data needed, sample and analysis options and data quality indicators for the OU 11 Phase I RFI/RI.

4.2.1 Identify Data Uses

RFI/CMS and RI/FS data can be categorized according to use for the following general purposes:

- Site characterization;
- Health and safety practices;
- Risk assessment;
- Evaluation of alternatives;
- Engineering design of alternatives;
- Monitoring during remedial action; and
- Determination of potentially responsible parties (PRPs).

Because this Work Plan describes a Phase I RFI/RI, data uses such as engineering design and monitoring during remediation (both remedial action activities) will be addressed in the Phase II RFI/RI workplan. The data use for PRP determination is not necessary for the OU 11 Work Plan. The remaining four data uses will be important in meeting the objectives identified in Section 4.1.4. Data uses for specific sampling and analysis activities for the Phase I investigation at OU 11 are listed in Table 4-1. Information obtained during the OU11 RFI/RI investigation will be available for use in other RFI/RI activities at Rocky Flats. Health and safety requirements presented in the site-wide Health and Safety plan will be followed under the OU11 RFI/RI investigation.

4.2.2 Identify Data Types

Data types can be initially divided into broad groups and again divided into more specific components. Examples of data types include field screening data, and physical and hydrogeologic, and chemical data.

For the Phase I RFI/RI investigation, surficial soil, and subsurface unconsolidated material, and sediment samples will be collected. A radiation survey will be conducted over the West Spray Field area. These data types will provide Phase I RFI/RI information to further characterize physical features and contamination at OU 11. Selection of chemical analyses has been based on the objectives of the Phase I program and on the past activities at the West Spray Field. Data types are listed in Table 4-1.

4.2.3 Identify Data Quality Needs

EPA defines five levels of data analysis, listed as follows (U.S. EPA, 1987):

- Level I - Field screening or analysis using portable instruments. Results are often not compound-specific and not quantitative, but results are available in real time. It is the least costly of the analytical options.

- Level II - Field analysis using more sophisticated portable analytical instruments; in some cases, the instruments may be set up in a portable on-site laboratory. There is a wide range in the quality of the data that can be generated. The quality depends on the use of suitable calibration standards, reference materials, and sample preparation equipment and on the training of the operator. Results are available in real time or within several hours.

- Level III - All analysis performed in an off-site laboratory. Level III analyses may or may not be performed according to CLP procedures, but the validation or documentation procedures required of CLP Level IV analysis are not usually utilized. The laboratory may or may not be a CLP laboratory.

- Level IV - CLP routine analytical services (RAS). All analyses are performed in an off-site CLP analytical laboratory following CLP protocols. Level IV is characterized by rigorous QA/QC protocols and documentation.

- Level V - Analysis by non-standard methods. All analyses are performed in an off-site analytical laboratory that may or may not be a CLP laboratory. Method development or method modification may be required for specific constituents or detection limits. CLP special analytical services (SAS) are Level V.

All five levels of data analysis will be necessary for performing Phase I field activities. Table 4-2 specifies the analysis which will be employed for each of the planned Phase I RI/RFI tasks. The appropriate levels based on the data need and data use, have been specified in Table 4-1. Additionally, the level of analysis must meet required detection limits for completing a Baseline Risk Assessment.

Data quality for the Phase I RFI/RI will be achieved by meeting the requirements for Level I through V data outlined in EG&G Rocky Flats General Radiochemistry and Routine Analytical Services Protocol (GRRASP) (EG&G, 1991) and the suggested guidelines outlined in the Guidance for Data Useability In Risk Assessment (U.S. EPA, 1990e), and by adhering to the data collection protocols provided in agency-approved EMD Operating Procedures or EMD-OPS (previously Standard Operating Procedures or SOPs), Quality Assurance Project Plan or QAPjP and Document Change Notices or DCNs (previously Procedure Change Notices or PCNs).

4.2.4 Identify Data Quantity Needs

Data quantity needs were determined based primarily on an evaluation of the information available from past studies conducted for purposes of characterizing the site physical features and contamination at OU 11. This is consistent with guidance provided in Data Quality Objectives for Remedial Response Activities (U.S. EPA, 1987) and Guidance for Data Useability in Risk Assessments (U.S. EPA, 1990). The rationale for sampling quantities is described in the FSP presented in Section 7.0 of this Work Plan.

To ensure that a sufficient amount of valid data are generated, the FSP was designed to include: (1) a rationale for all field activities based on an evaluation of the existing information, (2) a staged approached using screening-level techniques to identify and/or locate critical sampling sites or need to utilize more intensive investigative techniques, and (3) contingency plans for obtaining data from critical locations. These components of the FSP are discussed further in Section 7.0.

4.2.5 Evaluate Sampling/Analysis Options

To ensure that sufficient and adequate data are collected, the Phase I RFI/RI for OU 11 presents a stepped, or phased, approach in which field screening techniques (e.g., Level I and II data types) will be used to direct data collection activities designed to obtain Level III through V data. This stepped program has been designed to be consistent with the IAG schedule.

This approach maximizes collection of useful data because field screening techniques will be used to properly locate and minimize intrusive data collection activities such as borehole drilling. Additionally, this approach minimizes the volume of hazardous waste material generated that requires special management, the potential exposure of field personnel to hazardous waste material, and the overall time to perform the field activities.

Two types of activities will be performed during the Phase I field investigation: (1) screening activities, and (2) sampling activities. Screening activities (Levels I and II) include visual inspection, a radiological survey, and geotechnical analyses. Sampling and analyses of surficial soils, subsurface materials, and sediments will provide Level III through Level V data.

Sampling options for the Phase I RFI/RI were selected on the basis of their ability to: (1) obtain data consistent with the DQOs in the least intrusive manner, (2) obtain multiple types of data at each sampling location, and (3) reduce the waste generated at each sampling location and to minimize long-term maintenance and care.

4.2.6 Review of PARCC Parameter Information

PARCC (precision, accuracy, representativeness, completeness, and comparability) parameters are indicators of data quality. Precision, accuracy, and completeness goals have been established for this Work Plan based on the analyses being performed and the required analytical levels. PARCC goals are specified in the Quality Assurance Addendum (QAA) which will be submitted under separate cover for this Work Plan.

In the quantitative Human Health Risk Assessment and the Environmental Evaluation, only data that have been reviewed and have been determined to meet the minimum data quality requirement can be used. A summary of the minimum requirements for data quality indicators is presented in Table 4-3. This table provides a description of the potential impact of unacceptable data to the Human Health Risk Assessment and the suggested corrective action. The criteria presented in Table 4-3 will be used to evaluate the useability of the data collected from the OU 11 field sampling program.

The analytical program requirements for OU 11 are discussed in Section 7.4 of this Work Plan. The GRRASP and the RFP site-wide QAPjP provide listings of the CLP analytes and detection/quantification limits for Target Compound List (TCL) volatile organics, semivolatile organics, Target Analyte List (TAL) metals, radionuclides, and inorganic parameters. These analytical methods are appropriate for meeting the data quality requirements for analytical Levels I through V during the Phase I RFI/RI. The precision, accuracy, and completeness parameters for analytical Levels I through V are discussed below, along with the completeness and representativeness for all analytical levels.

Precision measures the reproducibility of measurements under a given set of conditions. Accuracy measures the bias or source of error in a group of measurements. Precision and accuracy objectives for the analytical data collected for the Phase I RFI/RI at OU 11 will be evaluated according to the control limits specified in the referenced analytical method and/or in data validation guidelines. For the radionuclide analyses, the accuracy objectives specified in the GRRASP and the RFP site-wide QAPjP will be followed. The specified criteria for precision and accuracy are described in the QAA. Precision and accuracy for non-analytical data will be achieved through protocols outlined in agency-approved EMD-OPS and DCNs.

Completeness is defined as the percentage of measurements made that are judged to be valid. The target completeness objective for the OU 11 field and analytical data is 100 percent, although 90 percent will be the minimum acceptable level. The FSP was designed to generate a sufficient amount of valid data and to include: (1) a rationale for all field activities based on an evaluation of the existing information, and (2) a phased approach using screening level techniques to identify and/or locate critical sampling sites. These components of the FSP are discussed further in Section 7.0.

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared to another. In order to achieve comparability, work will be performed at OU 11 in accordance with approved sampling and analysis plans, standard analytical protocols, and approved EMD-OPS for data collection. Consistent units of measurement will be used for data reporting.

Representativeness expresses the degree to which sample data accurately and precisely represent the characteristics of a particular site or condition. Representativeness is a qualitative parameter related to the design of the sampling and analysis components of the investigative program. The FSP described in Section 7.0 of this Work Plan and the referenced SOPs describe the rationale for the sampling program to provide for representative samples.

4.3 STAGE 3 - DESIGN DATA COLLECTION PROGRAM

The purpose of Stage 3 of the DQO process is to design the specific data collection program for the Phase I RFI/RI for OU 11. To accomplish this in accordance with the IAG, the elements identified in Stages 1 and 2 were assembled and the Sampling and Analysis Plan (SAP) and Field Sampling Plan (FSP) were prepared.

The SAP consists of: (1) a Quality Assurance Project Plan (QAPjP) (EG&G, 1991g) that describes the policy, organization, functional activities, and QA/QC protocols necessary to achieve the DQOs dictated by the intended use of the data; (2) EMD-OPS that describe specific sampling techniques to accomplish a specific objective, sampling equipment and procedures and general sample handling and analysis procedures. The QAPjP and EMD-OPS were developed and approved under the site-wide RFI/RI work. The FSP provides guidance for all field work by defining in detail the sampling and data collection methods to be used in the Phase I RFI/RI for OU 11. The QAPjP and EMD-OPS were developed as part of the Rocky Flats site-wide RFI/RI work and are to be used in conjunction with the OU11 Work Plan.

The FSP is presented in Section 7.0 of this Work Plan which provides a detailed discussion of all samples to be obtained for each media and includes sample type, number of samples, sample location, analytical methods, and QA/QC samples. The field sampling plan is based on a progressive sampling approach starting with investigating surficial soils and sediments prior to investigating the vadose zone via test pit excavation. If it is determined that contamination is present in the vadose zone, borehole drilling will be initiated to better define the nature of the contamination in the vadose and saturated zones. Monitoring wells will be installed as part of the Phase II RFI/RI if data collected from the Phase I investigation indicates contamination is present and an expanded monitoring well network is necessary.

The site-wide SAP was used as the basis for development of the OU-specific SAP composed of the Quality Assurance Addendum (QAA) and the Standard Operating Procedures Addendum (SOPA). The QAA and SOPA were provided with each OU Work Plan where procedures described in the FSP require changes from the site-wide SAP. The QAA will be provided under separate cover for this Work Plan. The field activities presented in this work plan do not require SOPAs. Future changes to approved procedures or work plans will be submitted to the regulatory agencies for approval as EMD Controlled Document Revision Requests (CDRR). For urgent or temporary changes to and deviations from documents that provide instructions for conducting work, Document Change Notices (DCNs) will be submitted to the regulatory agencies for approval.

TABLE 4-1

DATA QUALITY OBJECTIVES AND NEEDS
Operable Unit 11

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed
Characterize Site Physical Features					
Evaluate existing and ongoing geologic investigations	-Define bedrock surface, subsurface alluvial channels	-Review existing data and ongoing site-wide geologic characterization studies	NA	-Site Characterization hydrogeologic conceptual model -Risk Assessment assess potential pathways	Primary Pathway -groundwater
Characterize Nature of Contamination in Surface Soils					
Radiation Survey	-Field Screening for health and safety -Verification of aerial survey -Identification of potential radionuclide contamination in surficial soils within WSF boundaries	-Conduct radiation survey and collect soil samples for radionucide profile and concentrations	II-Radiation Survey V-Radionuclides	-Health and safety -Site Characterization	Primary Pathway -air Secondary Pathway -biota
Surfacial Soil Samples	-Characterize potential contamination in surficial soil within WSF boundaries	-Collect soil samples and analyze for: TAL metals, inorganics, and nitrates	IV-TAL metals, inorganics, and nitrates	-Site Characterization -Risk Assessment -Environmental Evaluation -Evaluate Remedial Alternatives	Primary Pathway -air Secondary Pathway -surface water -vadose zone -ground water -biota
Characterize Nature and Vertical Extent of Contaminants in *Subsurface Materials* - Vadose Zone					
Test Pit Samples	-Characterize potential contamination in vadose zone underlying boundaries of WSF -Characterize fate and transport of contaminants in unsaturated zone	-Collect soil samples and analyze for Pu, Am, U, gross α, gross β, Tritium, TAL metals, inorganics, nitrates, and TCL volatiles and semivolatiles -Conduct geotechnical testing	I-Geologic characterization of vadose zone II-Grain size, density, moisture content, grading, plasticity IV-TAL metals, inorganics, nitrates, TCL volatiles and semivolatiles V-Radionuclides	-Site Characterization geologic conceptual model; nature of contamination -Risk Assessment asses potential pathway and transport -Environmental Evaluation -Evaluate Remedial Alternatives	Primary Pathway -vadose zone Secondary Pathway -ground water -biota

TABLE 4-1 (cont.)

DATA QUALITY OBJECTIVES AND NEEDS
Operable Unit 11

Data Item	Data Need	Activity	Analytical Level	Data Use	Conceptual Model Pathway Addressed
Boreholes *If contamination is present in test pit samples.	-Characterize identified contamination in vadose zone underlying spray application areas within WSF -Characterize fate and transport of contaminants in vadose zone underlying spray application areas within WSF	-Collect soil samples and analyze for Pu, Am, U, gross α, gross β, Tritium, TAL metals, inorganics, nitrates, and TCL volatiles and semivolatiles	I-Geologic characterization of vadose zone IV-TAL metals, inorganics, nitrates, TCL volatiles and semivolatiles V-Radionuclides	-Site Characterization geologic conceptual model; nature of contamination -Risk Assessment asses potential transport -Environmental Evaluation -Evaluate Remedial Alternatives	Primary Pathway -vadose zone Secondary Pathway -ground water
Characterize Nature of Contamination in Sediment					
Sediment Samples	-Characterize potential contamination in sediment	-Collect sediment samples in identified historic surface water runoff areas within the WSF boundaries and along historic breeched berm at Walnut Creek -Collect soil samples and analyze for Pu, Am, U, gross α, gross β, Tritium, TAL metals, inorganics, and nitrates,	IV-TAL metals, inorganics, nitrates V-Radionuclides	-Site Characterization -Risk Assessment assess potential transport pathway and exposure through ingestion and dermal contact -Environmental Evaluation -Evaluate Remedial Alternatives	Primary Pathway -groundwater -historic surface water runoff

TABLE 4-2

LEVEL OF ANALYSIS
OPERABLE UNIT NO. 11

REQUIRED ANALYTICAL LEVEL	TASK
Level I (Field Screens)	- Water level measurement - pH measurement (field) - Temperature (field) - Specific conductance (field)
Level II (Field Analyses)	- Analysis of geotechnical properties - Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	- Major ion analysis - Organics analysis - Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	- Analysis of Target Compound List (TCL) and Target Analyte List (TAL)
Level V (Nonstandard Analyses)	- Radiological analyses - Contaminant analyses requiring modification of standard methods - Special Analytical Services (SAS) - Bioaccumulation in biota (TAL metals) - Biological analyses

Source: Modified from U.S. EPA (1987)

TABLE 4-3

MINIMUM REQUIREMENTS, IMPACT, AND CORRECTIVE ACTIONS FOR DATA USEABILITY CRITERIA OPERABLE UNIT NO. 11

DATA USEABILITY CRITERION	MINIMUM DATA QUALITY REQUIREMENT	POTENTIAL IMPACT ON RISK ASSESSMENT	SUGGESTED CORRECTIVE ACTION
Reports to Risk Assessor	- Site description - Sample design with sample locations - Analytical method and detection limit - Results on per-sample basis, qualified for analytical limitations - Sample-specific quantitation limits (SQLs) and detection limit for nondetects - Field conditions for media and environment - Preliminary	- Unable to perform quantitative risk assessment	- Request missing information - Perform qualitative risk assessment
Documentation	- Sample results related to geographic location (chain-of-custody records, SOPs, field and analytical records)	- Unable to assess exposure pathways - Unable to identify appropriate concentration for exposure areas	- Request locations identified - Resampling
Data Sources	- Analytical data results for one sample per medium per exposure pathway - Broad spectrum analysis for one sample per medium per exposure pathway - Field measurements data for media and environment	- Potential for false negatives and positives - Increased variability in exposure modeling	- Resampling or reanalysis for critical samples
Analytical Method and Detection Limit	- Routine methods used for critical samples and chemicals of potential concern - Detection limit less than 20 percent of concentration of concern	- Unquantified precision and accuracy - False negatives	- Reanalysis - Resampling and analysis for critical samples - Documented statements of limitation for noncritical samples
Data Review	- Correctness of analytical results reviewed	- Potential for false negatives or false positives - Increased variability and bias because of analytical process, calculation, or transcription errors	- Perform data review
Data Quality Indicators	- Sampling variability quantified for each analyte - QC samples required to identify and quantify precision and accuracy - Sampling and analytical precision and accuracy quantified	- Unable to quantify confidence levels for uncertainty - Potential for false negatives or false positives	- Resampling for critical samples - Perform qualitative risk assessment - Perform quantitative risk assessment for noncritical samples with documented discussion of potential limitations

Source: Guidance for Data Useability In Risk Assessment (EPA, 1990).

5.0 RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION TASKS

5.1 TASK 1 - PROJECT PLANNING

Project planning for the implementation of the Phase I RFI/RI for OU11 will include numerous activities in addition to tasks completed as part of this Work Plan. Review of previous site investigations, preliminary site characterization, preliminary identification of potential ARARs and the development of Data Quality Objectives and a FSP have all been completed as part of this Work Plan and are contained in Sections 2.0, 3.0, 4.0, and 7.0.

Prior to performing field investigations, it will be necessary to review any new information that becomes available after the preparation of this Work Plan. Field activities proposed for OU11 will be integrated with ongoing or proposed field activities for other overlapping investigation sites to minimize redundancy and maximize efficiency.

It is important to emphasize that project planning and coordination will be required throughout the project duration as unforseen developments occur.

5.2 TASK 2 - COMMUNITY RELATIONS

In accordance with the IAG, the RFP is developing a Community Relations Plan (CRP) to inform and actively involve the public in decision-making as it relates to environmental restoration activities. The vehicle for public involvement in the RFI/RI process is through the Technical Review Group process. The CRP will address the needs and concerns of the surrounding communities as identified through approximately 80 interviews with federal, state, and local elected officials; businesses; medical professionals; educational representatives; interest groups; media; and residents adjacent to the RFP.

A Draft CRP was issued for public comment in January 1991.

Current community relations activities concerning environmental restoration include participation by plant representatives in informational workshops; presentations at meetings of the Rocky Flats Environmental Monitoring Council; briefings for citizens, businesses, and surrounding communities on environmental restoration and monitoring activities; and public comment opportunities on various EM Program plans and actions. RFP personnel involve several special interest groups in decisions that pertain to environmental restoration activities, including the Rocky Flats Cleanup Commission, the recipient of the EPA Technical Assistant Grant.

In addition, a Speakers' Bureau program provides plant speakers to civic groups and educational organizations, and a public tours program allows the public to visit the RFP. The RFP also produces fact sheets and periodic updates on environmental restoration activities for public information and responds to numerous public inquiries regarding the RFP.

5.3 TASK 3 - FIELD INVESTIGATION

The Phase I RFI/RI field investigation is designed to meet the objectives outlined in Section 4.0 of this Work Plan. Additionally, the data will be used to support the Phase I Environmental Evaluation and the Phase I Baseline Human Health Risk Assessment. The activities described below will be performed as part of the field investigation, as described in detail in Section 7.0.

The scope of the Phase I field investigation is to characterize the contaminant sources within OU11. The Phase I field investigation will include the following subtasks conducted in sequential stages:

5.3.1 Existing Data Compilation

Newly generated data and historical data which become available after preparation of this Work Plan will be compiled to take advantage of the most current unit and site information.

5.3.2 Facility Coordination and Mobilization

During the mobilization for field work, detailed planning to coordinate with facility operations will be performed.

Coordination will be required between field sampling personnel and Access Control to provide access for personnel and equipment. Site Safety Officers will be notified of field activities in order to better provide assistance in the event of an emergency. Any required notifications will be made to the Regulatory Agencies, so that observers may be scheduled.

5.3.3 Radiation Survey

A ground-based gamma radiation survey will be conducted over the entire OU11 area and 100 feet beyond the area boundaries. A germanium detector will be utilized at locations on 150 foot grid lines in order to verify results of the previous aerial radiation survey, locate potential "hot" spots and soil sample locations. Further surveys using tighter grid spacings will be conducted in areas indicating above-background radioactivity in the initial sampling.

5.3.4 Surface Soil Samples

The entire West Spray Field area will be subject to surface soil sampling on a 300-foot grid spacing. A total of 75 samples will be collected. Each sample will consist of composited soil from ten locations in two, one-meter square areas. The samples will be analyzed for nitrates, metals, and inorganics.

5.3.5 Vadose Zone Test Pit Soil Samples

Test pits will be located to evaluate soil from the surface to a depth of approximately four feet. Soil will be evaluated for physical properties, inorganics, organics and radionuclides. Trenches are being used in order to make observations of soil characteristics and collect composite samples over a larger area than a borehole, and to allow accurate measurement of sample depth.

5.3.6 Vadose Zone Borehole Soil Samples

Vadose zone boreholes will be drilled if contamination is detected in the test pit soil samples. The number and location of samples for chemical analysis will depend on the number and location of test pits found contain contaminated soil.

5.3.7 Sediment Samples

Sediment samples will be collected in areas of historic spray application and surface water runoff away from these areas. Each sample will be a composite sample from a maximum depth of two feet. The analyses to be conducted on the sediment samples include nitrate, metals, inorganics and radionuclides.

5.4 TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION

Analytical procedures will be completed in accordance with the ER Program QAPjP (EG&G, 1991g). Analytical detection limits, sample container and volume requirements, preservation requirements, and sample holding times are discussed in Section 7.4 of the FSP.

Results of data review and validation activities will be documented in data validation reports. EPA data validation functional guidelines will be used for validating organic and inorganic (metals) data (U.S. EPA, 1988c). Data validation methods for radiochemistry and major ions data have not been published by EPA, but data and documentation requirements have been developed by EM Program QA staff. Data validation methods for these data are derived from these requirements. Details of the data validation process are described in the QAPjP (EG&G, 1991g).

Phase I data will be reviewed and validated according to data validation guidelines in the QAPjP and the Data Validation Functional Guidelines (EG&G, 1990d). These documents state that the results of data review and validation activities will be documented in data validation reports.

5.5 TASK 5 - DATA EVALUATION

Data collected during the Phase I RFI/RI, as well as previously collected data, will be incorporated into the existing RFEDS database and will be used to better characterize contaminant sources and soil. These results also will be used in delineating the requirements for the Phase II RFI/RI plans for determining the impact of OU11 on surface water, groundwater, air, the environment, and biota, as well as the potential contaminant migration pathways at OU11. Additionally, data will be used to support the evaluation of proposed remedial alternatives and the Baseline Risk Assessment.

5.5.1 Site Characterization

The additional data collected during Phase I will be incorporated into the existing site characterization. Physical and chemical data will be used in the delineation of the presence of contamination in surface and subsurface soils within OU11.

5.5.2 Source and Soils Characterization

Analytical data from unconsolidated material samples and surficial soils will be used to:

- Characterize the nature of source contaminants;
- Characterize the lateral and vertical extent of source contaminants;
- Evaluate on-site contaminant concentrations; and
- Quantify the volume of source material.

Analytical data obtained from samples of soils will be used to characterize the sources of contamination. Data will be summarized graphically and/or in tabular form to assist interpretation. If appropriate, contaminant isopleth maps will be prepared to summarize the spatial distribution of source and soil contaminants.

The criteria for the identification of contamination will be analyte-specific for each geologic unit (such as the Rocky Flats Alluvium, Colluvium, or artificial fill). For all analytes (including radionuclides), only those concentrations that exceed the site-specific background concentrations will be considered likely evidence of contamination. These data will be compared to site wide background values provided in the Background Geochemical Characterization Report (EG&G, 1991a).

5.6 TASK 6 - PHASE I BASELINE RISK ASSESSMENT

As required by the IAG, a Baseline Risk Assessment that will address the risk associated with source and soils will be performed as part of the Phase I RFI/RI report. The Baseline Risk Assessment includes a Human Health Risk Assessment and an Environmental Evaluation for OU11. The purpose of the Human Health Risk Assessment and Environmental Evaluation are to assess the potential human health and environmental risks associated with the site and to provide a basis for determining whether remedial actions are necessary. In accordance with the IAG, risks will be calculated at the source. The Human Health Risk Assessment will address potential public health risks, and the Environmental Evaluation will address environmental impacts.

Existing data and data collected during the Phase I RFI/RI will be used to support the quantitative Human Health Risk Assessment and Environmental Evaluation. The sampling program will be designed to generate data that meet the requirements set forth in Guidance For Data Useability In Risk Assessment (U.S. EPA, 1990).

These assessments will aid in the preliminary screening of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment. The risk assessment process will be accomplished in five general steps:

1. Identification of chemicals of concern;
2. Exposure assessment;
3. Toxicity assessment;
4. Risk characterization; and
5. Qualitative and quantitative uncertainty analysis.

As stated in the IAG, a risk characterization of the following scenarios will be developed:

1. Current site conditions (No Action Alternative);
2. Worker and public exposure during remedial action;
3. Past remedy risk; and
4. Potential future use.

If the Human Health Risk Assessment and Environmental Evaluation determine that risks posed by contamination at OU11 must be remediated, Tasks 7 and 8 will be conducted.

The objectives and the description of work for the Human Health Risk Assessment are described in detail in Section 8.0 of this Work Plan. The Environmental Evaluation Work Plan is presented in Section 9.0.

5.7 TASK 7 - DEVELOPMENT, SCREENING, AND DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

5.7.1 Remedial Alternatives Development and Screening

This section identifies potential technologies applicable to remediation of contaminated soils and groundwater within and affected by OU11. The identified technologies are based on the preliminary site characterization developed in Section 2.0. Identification and screening of technologies, assembling an initial screening of alternatives, and identification of interim response actions will be conducted while the Phase I RFI/RI is being conducted. However, investigation of this operable unit is in its early stages; thus, remedial alternatives are only briefly reviewed in this section. A more detailed evaluation of the remedial alternatives for OU11 will be performed as more data are collected.

The process employed to develop and evaluate alternatives for OU11 will follow guidelines provided in the National Contingency Plan (NCP). Although RCRA regulations will direct remedial investigations at OU11, the CERCLA process will also be considered for guidance because it specifies in greatest detail the steps that should be followed for selection of remedial alternatives. In addition, the IAG requires general compliance with both RCRA and CERCLA guidance.

The steps followed to develop remedial alternatives for OU11 are as follows:

1. Develop a list of general types of actions appropriate for OU11 (such as containment, treatment, and/or removal) that may be implemented to satisfy the objectives defined in the previous step. These general types or classes of actions are generally referred to as "general response actions" in EPA guidance.

2. Identify and screen technology groups for each general response action. Screening will eliminate groups that are not technically feasible at the site.

3. Identify and evaluate process options for each technology group to select a process option representing each technology group under consideration. Although specific process options are selected to represent a technology group for alternative development and evaluation, these processes are intended to represent the broader range of options within a general technology group.

4. Assemble the selected representative technologies into site closure and corrective action alternatives for OU11 that represent a range of treatment and containment combinations, as appropriate.

5. Screen the assembled alternatives in terms of the short- and long-term aspects of three broad criteria: effectiveness, implementability, and cost. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo thorough and extensive analysis, alternatives will be evaluated in less detail than subsequent evaluations.

6. Develop preliminary cancer risk-based remedial action goals for affected media. Preliminary remedial action goals will be applied as performance objectives for evaluating the effectiveness of specific technology processes identified as candidate components of viable remedial action alternatives. Consistent with the

NCP, preliminary remediation goals will be established at a 1 x 10^{-6} excess cancer risk point of departure evaluated at the source. As the CMS/FS evolves, preliminary remediation goals may be revised to a different risk level on the basis of consideration of appropriate factors that include, but are not limited to, exposure, uncertainty, and technical issues.

7. Determine remediation goals associated with toxic, non-cancer risk using the appropriate reference dose for each chemical present on the site. A Hazard Index (HI) will then be calculated. If the HI exceeds 1.0, further investigation of preliminary remediation goals will be evaluated. If the HI is less than 1.0, a toxic risk does not exist at the site and remediation would not be required.

For the Phase I RFI/RI Work Plan, the appropriate level of alternatives analysis is the listing of general response actions most applicable to the type of site under investigation. General response actions are defined as those broad classes of actions that may satisfy the objectives for remediation defined for OU11. Table 5-1 provides a list and description of general response actions and typical technologies associated with remediating soils, groundwater, and surface water. Table 5-1 also includes a general statement regarding the applicability of the general response action to potential exposure pathways. Not all of the alternative response actions and typical technologies listed may be appropriate for OU11. Some will be discarded during the screening of alternatives.

The response actions outlined in Table 5-1 must be applied to the potential exposure pathways that will be identified for OU11. The response actions can be capable of providing control over all or some of the potential pathways. Partially effective response actions can be combined to form complementary sets of response actions that provide control over all pathways.

In general terms, potential human exposure can be avoided by prevention of contaminant release, transport, and/or contact. Thus, application of the response actions may be considered at three different points in each potential exposure pathway: (1) at the point where the contaminant could be released from the source, (2) in the transport medium, and (3) at the point where the contact could occur with the released contaminant.

The existing data do not adequately characterize the source, release mechanisms, and migration pathways for contamination at OU11. Therefore, the existing data are not sufficient for implementing the screening of alternatives. Phase I will generate data (Table 5.2) necessary to characterize the source and soils (as defined in Section 1.0). Phase II of the RFI/RI will evaluate the impact of OU11 on surface water, groundwater, air, the environment, and biota in addition to characterizing potential contaminant migration pathways. Data obtained from these investigations will:

- Describe the physical characteristics of the site;
- Define sources of contamination;
- Determine the nature and extent of contamination in soil, groundwater, surface water, and air;
- Describe contaminant fate and transport; and
- Describe receptors.

These data will provide information for the preliminary screening of alternatives and a thorough, comparative evaluation of the technologies with respect to implementability, effectiveness, and cost. This information will allow for informed decisions to be made with respect to the selection of preferred technologies. The FSP (Section 7.0) describes the methodology that will be followed to obtain the required information for the Phase I RFI/RI characterization.

5.7.2 Detailed Analysis of Remedial Alternatives

Sufficient data may not be generated during the Phase I investigation to allow for a detailed analysis of alternatives. The detailed analysis of each alternative will be performed when sufficient data are generated during Phase II. The detailed analysis and selection of alternatives is the process of analyzing and comparing relevant information in order to select a preferred remedial action. In accordance with the NCP, containment technologies will generally be appropriate remedies for wastes that pose a relatively low-level threat or where treatment is impracticable (U.S. EPA, 1991b). Each appropriate alternative will be assessed in terms of nine evaluation criteria, and the assessments will be compared to identify the key attributes among the alternatives. Assessment in terms of eight evaluation criteria is necessary for the CMS and the subsequent Corrective Action Decision (CAD)/Record of Decision (ROD). The nine specific evaluation criteria are as follows:

1. Overall protection of human health and the environment;
2. ARARs;
3. Long-term effectiveness and permanence;
4. Reduction of toxicity, mobility, or volume;
5. Short-term effectiveness;
6. Implementability;
7. Cost;
8. State acceptance; and
9. Community acceptance.

These criteria are described in recently revised guidelines provided in the NCP. The first two criteria are considered threshold criteria because they must be evaluated before further consideration of the remaining criteria. The next five criteria are considered the balancing criteria on which the analysis is based. The final two criteria are addressed during the final decision-making process after completion of the CMS/FS.

5.8 TASK 8 - TREATABILITY STUDIES/PILOT TESTING

The primary purposes of a treatability study are to provide sufficient technology performance information and to reduce cost and performance uncertainties to acceptable levels so that treatment alternatives can be fully developed and evaluated during detailed analysis. The task includes efforts to evaluate whether treatability studies are necessary and, if so, to prepare for and conduct treatability studies. If remedial alternatives are developed, the data collected as part of the field investigation will be reviewed in terms of whether the alternatives can be evaluated. If additional data are required, treatability studies or field investigations will occur.

If it is determined that a treatability study is necessary, a treatability work plan will also be prepared. The plan will identify treatability tests that need to be conducted as well as the test materials and equipment needed.

The treatability work plan will discuss the following:

- The scale of the treatability study;
- Key parameters to be varied and evaluated, and criteria to be used to evaluate the tests;
- Specifications for test samples, and the means for obtaining these samples;
- Test equipment and materials, and procedures to be used in the treatability test;
- Identification of where and by whom the tests and any analytical services will be conducted, as well as any special procedures and permits required to transport samples and residues and conduct the test;
- Methods required for residue management and disposal; and
- Any special QA/QC needed for the tests.

5.9 TASK 9 - PHASE I RFI/RI REPORT

The Phase I RFI/RI report will be prepared to consolidate and summarize the data obtained during the Phase I fieldwork as well as data collected from previous and ongoing investigations. The Phase I RFI/RI report will consist of a Preliminary Site Characterization Summary and a BRAP of the West Spray Field. This report will:

- Describe the field activities that serve as a basis for the Phase I RFI/RI report. This will include the scope of the Phase I investigation and any deviations from the Work Plan that occurred during implementation of the field investigation.

- Discuss site physical conditions based on existing data and data derived during the Phase I RFI/RI. This discussion will include surface features, climate, surface water hydrology, surficial geology (vadose-zone soils), geotechnical soil index properties and classification, stratigraphy, groundwater hydrology, demography and land use, and ecology.

- Present site characterization results from all Phase I RFI/RI activities to characterize the site physical features and contamination at OU11. The media to be addressed will be limited to contaminant source and soils.

- Discuss contaminant fate and transport based on existing information. This discussion will include a preliminary identification of potential contaminant migration routes, release sources and mechanisms, and a discussion of contaminant persistence, chemical attenuation processes, and potential receptors.

- Present a Phase I BRAP. The BRAP will include human health and environmental evaluations.

- Present a summary of findings and conclusions.

- Identify data needs for Phase II of the RFI/RI, if necessary.

Before submittal of the Phase I RFI/RI report, a Preliminary Site Characterization Summary will be submitted to EPA and CDH for review. This summary will provide an early description of the initial site characterization effort, including a preliminary presentation of analytical data and a listing of chemical and radiological contaminants, the affected media, and potential site wide chemical-specific ARARs. In addition to the characterization summary, technical memoranda will be prepared with the completion of each field sampling task to provide preliminary results of field investigations.

TABLE 5-1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical General Response Technologies	Action to Potential Pathways
No Action	No remedial action taken at site	Some monitoring and analyses may be performed.	National Contingency Plan requires consideration of no action as an alternative. Would not address potential pathways, although existing access restriction would continue to control on-site contact.
Access and use restrictions	Permanent prevention of entry into contaminated area of site. Control of land use.	Site security; fencing, deed use restrictions; warning signs.	Could control on-site exposure and reduce potential for off-site exposure. Some site security fencing and signs are in place. Additional short-term or long-term access restrictions would likely be part of most remedial actions.
Containment	In-place actions taken to prevent migration of contaminants.	Capping; ground water containment barriers; soil stabilization; enhanced vegetation.	If applied to source, could be used to control all pathways. If applied to transport media, could be used to mitigate past releases (except air).
Pumping	Transfer of accumulated subsurface or surface contaminated water, usually to treatment and disposal.	Ground water pumping.	Applicable removal of contaminated ground water.
Removal	Excavation and transport of primarily nonaqueous contaminated material from area of concern to treatment or disposal area.	Excavation and transfer of soils, contaminated structures.	If applied to source, could be used to control all pathways. If applied to transport media, will control corresponding pathway. Must be used with treatment or disposal response actions to be effective.
Treatment	Application of technology to change the physical or chemical characteristics of the contaminated material. Applied to material that has been removed.	Solidification; biological, chemical, and physical treatment.	Applied to removed source material; could be used to control all pathways. Applied to removed transport media, could control air, surface water, ground water, and sediment pathways.

TABLE 5.1 (continued)

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical General Response Technologies	Action to Potential Pathways
In-Situ Treatment	Application of technologies in-situ to change the in-place physical or chemical characteristics of contaminated material.	In-situ vitrification; bio-remediation.	Applied to source, could be used to control all pathways. Applied to transport media, could be used to control corresponding pathways.
Storage	Temporary stockpiling of removed material in a storage area or facility prior to treatment or disposal.	Temporary storage structures.	May be useful as a means to implement removal actions, but definitely would not be considered a final action for pathways.
Disposal	Final placement of removed contaminated material or treatment residue in a permanent storage facility.	Permitted landfill; repositories.	With source removal, could be used to control all pathways. With removal of contaminated transport media, could be used to control corresponding pathway (except air).
Monitoring	Short-and/or long-term monitoring is implemented to assess site conditions and contamination levels.	Sediment, soil, surface water, and ground water sampling and analysis.	RCRA requires post-closure monitoring to assess performance of closure and corrective action implementation.

TABLE 5-2

RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Complete or partial removal and treatment of contaminated soils	• Disposal (off-site)	Evaluate RCRA land ban and radio-activity restrictions	- 40 CFR 268 Table CCWE and Appendix III Analyses - Full suite of radionuclide analyses
		Cost analysis	- Vertical and horizontal extent of contamination
In-situ contaminated soils treatment	• Immobilization	Determine viscosity of grout material	- Soil grain size distribution (sieve analysis)
		Effectiveness	- Full suite of organic and inorganic analyses
	• Soil flushing	Effectiveness	- Full suite of organic and inorganic analyses - Soil organic matter content - Soil classification - Soil permeability - Treatability study
	• Vapor extraction	Effectiveness	- Full suite of organic and inorganic analyses - Subsurface geological characteristics - Depth to ground water - Soil permeability - Treatability
	• Vitrification	Cost effectiveness	- Full suite of organic and inorganic analyses - Treatability study
Ground water collection	• Well array/subsurface drains	Storativity (transient flow)	- Aquifer tests

TABLE 5-2 (continued)

RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Infiltration and ground water containment controls	• Capping/subsurface barriers	Suitability of off-site soil for use	- Gradation (sieve analysis) - Atterberg limits (plasticity tests) - Percent moisture - Compaction (proctor) - Permeability (triaxial permeability) - Strength (triaxial or direct shear)
		Effectiveness	- Location of subcropping sandstones - Hydraulic conductivity of bedrock materials
		Construction feasibility	- Grade - Depth to bedrock
In-situ ground water treatment/immobilization	• Immobilization	Determine viscosity of grout material	- Soil grain size distribution (sieve analysis)
		Effectiveness	- Full suite of organic and inorganic analyses
	• Aeration	Effectiveness	- Full suite of organic and inorganic analyses - Subsurface geological characteristics - Depth to ground water - Soil permeability - Treatability study

TABLE 5-2 (continued)

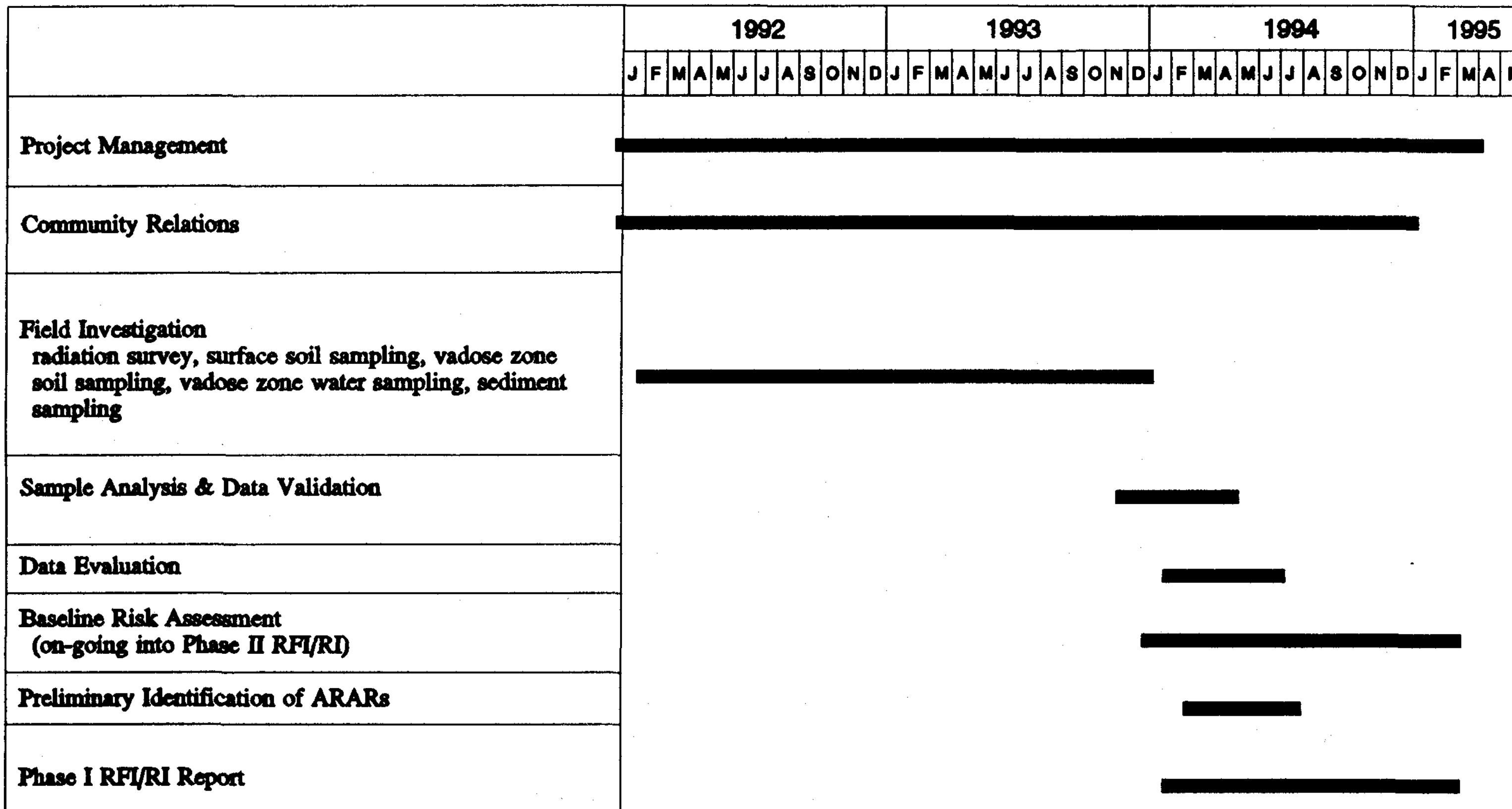
RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES, AND DATA REQUIREMENTS

General Response Actions	Associated Remedial Technologies	Data Purpose	Data Need
Ground water/surface water treatment	• UV/peroxide or UV/ozone	Process control	- Iron and manganese
		Effectiveness	- Full suite of organic and inorganic analyses - Treatability study
	• Air stripping	Process control	- Hardness
		Effectiveness	- Full suite of organic and inorganic analyses - Treatability study
	• Other water treatment technologies (carbon adsorption, ion exchange, electrodialysis, and reverse osmosis)	Process control	- Full suite of organic and inorganic analyses
		Effectiveness	

6.0 SCHEDULE

The Phase I RFE/RF schedule for OU11 is outlined in the following figure (Figure 6-1).

FIGURE 6-1
PHASE I RFI/RI SCHEDULE FOR OU11



* See Figure 9-9 for Environmental Evaluation Work Plan Schedule

U.S. DEPARTMENT OF ENERGY, ROCKY FLATS
PHASE I, RFI/RI FOR OPERABLE UNIT #11
WEST SPRAY FIELD

Sheet 1 of 1

Project Start: 2Jan92
Project Finish: 1Mar95

Data Date: 11Aug90
Plot Date: 17Dec91

7.0 FIELD SAMPLING PLAN

The Field Sampling Plan (FSP) outlines the activities which will be performed to generate sufficient and adequate data to satisfy the Phase I RFI/RI objectives developed in Section 4.0. These site-specific objectives are presented in Section 7.1. Current site conditions and a discussion of the rationale for the sampling and analysis activities needed to obtain the necessary data to meet the Phase I objectives are summarized in Section 7.2.

The field sampling program is organized by the media which were potentially impacted by the spray application and the investigative method selected to best characterize the site physical conditions and contamination. The sampling activities proposed to meet the Phase I RFI/RI objectives will be performed in a staged approach to allow modifications in implementing the Phase I sampling plan based on findings from each activity. Table 7-1 summarizes the OU11 RFI/RI field activities and sample analysis requirements.

Upon completion of each stage of field investigation, the data will be evaluated for adequacy and completeness with respect to the data quality objectives for the activity. Additionally, the data will be evaluated to determine the need to complete subsequent field sampling activities as presented in this work plan. The source characterization and site physical conditions will be evaluated in regard to contaminants present and potential contaminant migration, pathways and receptors. Decisions to alter the FSP may be made in order to optimize data quality and useability for refinement of the site conceptual model and risk assessment. Each stage thus becomes a decision point for potential modification of the FSP. DOE will keep CDH and EPA appraised of sampling decisions by submitting technical memoranda and CDRRs, if necessary. As outlined in Section VI. B. of the IAG Statement of Work, modifications to the work plan are submitted to the regulatory agencies for approval as amendments to the work plan.

Planned field sampling activities include:

- Radiological survey and surficial soil sampling of West Spray Field area;
- Vadose zone characterization by soil sampling from test pit excavations and potential borehole drilling;
- Sediment sampling of surface runoff channels within West Spray Field boundaries; and
- Implementation of IPPCD or PPCD requirements.

As part of the OU11 Work Plan, aerial photographs, historic reports, and OU4 source characterization data will be evaluated to verify the West Spray Field boundaries, areas of surface water runoff, potential data gaps, and chemistry of source waste streams.

The analytical program, including sample designations, analytical requirements, sample containers and preservation, sample labeling and documentation is discussed in Section 7.4. Data management and reporting requirements are described in Section 7.5, and Field Quality Control (QC) Procedures in Section 7.6. Air Monitoring Procedures to be followed during Phase I sampling activities are presented in Section 7.7. Health and Safety concerns for the Phase I RFI/RI will be addressed in a project-specific Health and Safety Plan, developed at a later date in accordance with EG&G's site-wide Health and Safety Program.

Phase II of the RFI/RI will use the characterization of source and soils information obtained in Phase I and will determine the nature and extent of contamination, describe contaminant fate and transport, and evaluate the impact of OU11 on surface water, groundwater, air, and biota. Phase II activities will be addressed in a separate Work Plan.

7.1 OU11 PHASE I RFI/RI OBJECTIVES

The specific objectives for characterizing source and soils in the Phase I RFI/RI field investigation for OU11 are as follows:

<u>Characterize Site Physical Features</u>

1. Delineate West Spray Field boundaries based on historic aerial photographs and reports, and review ongoing OU4 source characterization data from the OU4 RFI/RI studies that would impact OU11 sample analysis parameters.

2. Characterize subsurface soil composition and physical properties and determine the significance regarding contaminant migration.

3. Delineate the area of historic surface water runoff and evaluate the impact on contaminant migration.

<u>Define Contaminant Sources</u>

1. Determine the representative site-specific background concentrations of analytes in surface and subsurface soils.

2. Characterize contaminants and dispersion of contaminants in surficial soils within the West Spray Field boundaries.

3. Characterize location and type of contaminants in test pit soils and soil pore water within the West Spray Field boundaries.

4. Characterize location and type of contaminants in soils in runoff channels within the West Spray Field boundaries and breached areas.

Provide a Baseline Risk Assessment

The objectives of the Baseline Risk Assessment are discussed in Sections 8.0 and 9.0.

Provide an Environmental Evaluation

The objectives of the Environmental Evaluation are discussed in Section 9.0.

Determine The Nature and Extent of Contamination

The presence or absence of contamination in the sources will be determined through evaluation of the sampling and analyses of surface soil, sediment, test pit and possibly borehole samples. The nature and extent of contamination in groundwater within the West Spray Field boundaries and in all media outside the boundaries of the West Spray Field will be addressed in the Phase II RFI/RI Work Plan.

Determine Contaminant Fate and Transport

The fate and transport of contaminants within the West Spray Field boundaries will be addressed by evaluating the movement of key contaminant parameters within the vadose zone underlying the boundaries of the West Spray Field. Modeling will be used to predict movement and ultimate deposition of contaminants in the subsurface and surficial environments. Fate and transport of contaminants in the groundwater within the West Spray Field boundaries and all media outside the boundaries will be addressed in the Phase II RFI/RI Work Plan.

General Objective

A general objective of the Phase I RFI/RI Work Plan is to generate data necessary to determine the need for subsequent investigations and then begin development and screening of remedial alternatives, and to evaluate the need for the performance of treatability studies. Similarly the data will be used to determine risks to human health and the environment associated with the West Spray Field.

7.2 BACKGROUND AND FIELD SAMPLING PLAN RATIONALE

Previous investigations performed in the West Spray Field area and other pertinent information are summarized in Section 2.0 of this Work Plan. Available information at the site includes historical information on the West Spray Field use, aerial photographs, historical analytical results, soil sample results from test pits excavated in the area, stratigraphic logs, groundwater level measurements, groundwater analytical results from alluvial and bedrock wells and preliminary geophysical data.

The previous investigations have provided general information on physical characteristics of the site such as geologic structure and aquifer characteristics. A radiation survey, surficial soil sampling, subsurface soil sampling in test pit excavations and potential borehole drilling and sampling are proposed in this Phase I RFI/RI to provide information on physical site characteristics and contaminant nature.

Field Sampling Plan Rationale

Past spray activities may have resulted in contaminant deposition onto surficial soils within the West Spray Field area. Contaminants on the surface soils are subject to resuspension via the air pathway and thus require evaluation for the baseline risk assessment. In order to characterize the potential contamination due to radioactive and inorganic contaminants, a radiological screening survey will be conducted and surficial soil samples will be collected within the West Spray Field boundaries.

A radiation survey will be completed using a ground-based gamma survey by which gamma emitting isotopes are measured with a High Purity Germanium Crystal Detector. The radiation survey will be conducted on a grid spacing across the West Spray Field to verify results of a previous aerial and radiation survey, provide an indication of surficial radiation and to screen areas for health and safety purposes. The grid spacing will be such to allow 100 percent coverage of the survey area by allowing the field of view of the detector to overlap between data collection points. Evaluation of the survey results will indicate if further investigation is necessary to better characterize a potential hot spot by resurveying on a tighter grid spacing. Surficial soil samples will be collected along transects of the radiation grid to determine the presence or absence of non-gamma emitting radionuclides.

A separate surficial soil sampling task will be conducted to characterize metal and inorganic contaminant levels. Sampling will be along a systematic grid to identify potential contamination from direct spray application, surface water runoff or wind dispersion.

Test pits will be excavated within the West Spray Field boundaries to collect geotechnical information and contaminant characterization of the unconsolidated materials. EMD Operating Procedure GT.7 describes the procedures that will be followed for test pit excavation including logging, sampling, site restoration, surveying and decontamination tasks. If contamination is present within the test pit samples, borehole drilling will be used to further characterize the contamination. EMD Operating Procedure GT.7 is undergoing revision to tailor vadose zone characterization activities in OU2. The new procedures, will be submitted under separate cover to the regulatory agencies as DCNs to the currently approved EMD-OPS. These revised procedures will be implemented, where appropriate at OU11 after approval by the regulatory agencies.

Data considered pertinent to characterization of sources and soils are historical waste stream information, analytical results from previous test pit excavations, and physical parameters of the soils.

Characterization of site groundwater quality is not within the scope of the Phase I RFI/RI but will be investigated as part of the Phase II Work Plan per the IAG. The Phase II work will be coordinated with the State RCRA requirements for groundwater monitoring of the West Spray Field.

The rationale for the Phase I sampling activities is based on a stepped approach. Level I and Level II screening information, as defined in Section 4.0, will initially be acquired and used to direct subsequent intrusive sampling techniques that will provide Level III through V analytical results. For example, results of the radiological survey within the West Spray Field boundaries will be used to modify, if necessary, sample grid locations for the surficial soil sampling and test pit locations for analysis of the vadose zone. Similarly, vadose zone monitoring results will be used to guide further subsurface investigations by borehole drilling.

As part of the field sampling program, data from the site-wide monitoring programs will be used as appropriate to supplement the data collected during the Phase I investigation. These data include the results of quarterly sampling of existing monitoring wells and monthly sampling of surface water monitoring stations. Data resulting from the site-wide geologic characterization program will also be used, where possible. Air monitoring activities conducted site-wide or in specific response to the West Spray Field RFI/RI activities will also be included. The results of ongoing RFI/RI work at the other operable units identified in the IAG will be reviewed to optimize data collection and interpretation for OU11.

Analytical Methods Rationale

The analytical suites for each medium to be sampled in OU11 were developed according to the type of waste suspected to be present within that medium and discussed in Section 2.0. The rationale for the analytical suites is based on the contaminant behavior in the West Spray Field environment. The analytical requirements are presented in detail in Section 7.4.

Based on analyses of Solar Evaporation Pond water, metals, radionuclides, nitrates and possibly volatile organic compounds were potential contaminants in water sprayed at OU11. The behavior of these contaminant groups is briefly summarized from the OU4 RFI/RI Work Plan.

Alkali metal and alkaline earth elements such as potassium, sodium, calcium, magnesium and lithium are common dissolved metals in wastewater and in ground and surface water solutions and have been detected in water from the Solar Evaporation Ponds. Chemical precipitation of these metals can occur in the presence of major and minor anions such as chloride, sulfate, carbonate bicarbonate, nitrate and fluoride and through cation exchange within soil horizons. These anions have been detected in Solar Evaporation Pond water. Trace metals can also precipitate from solution in the presence of anions. Transport or mobility of dissolved metals is dependent on their initial concentrations in solution and the chemistry of the media through which the solution flows.

Transition metals such as cadmium, chromium, copper and nickel which have been detected in Solar Evaporation Pond water, can precipitate from solution in the presence of major anions. Mobility of these metals in solution is limited by adsorption to clays, organic matter and iron oxihydroxides present in soils. Thus, migration of transition metals is likely restricted to the subsurface soils.

Radionuclide mobility in the environment is dependent on oxidation-reduction and pH conditions. Some uranium isotopes are naturally occurring in soils and sediments in the Rocky Flats Plant area. Plutonium and americium form insoluble hydroxide and oxide solids under neutral and basic pH conditions which limit their mobility to the subsurface. However, colloidal transport of these radionuclides is also possible.

Nitrate concentrations were high in Solar Evaporation Pond water and are highly mobile in the environment and expected to be present in the subsurface. Volatile organics were detected in low concentrations in Solar Evaporation Pond water sprayed at the West Spray Field. Given the volatility of these chemicals, it is not likely that these contaminants would be present in the surficial soils at the West Spray Field.

7.3 FIELD SAMPLING PLAN DESIGN

The Phase I sampling activities at the West Spray Field are discussed as three related, but independent programs. They include:

1. OU-wide radiological survey and surficial sampling program (Section 7.3.1);
2. Vadose zone physical and contaminant characterization (Section 7.3.2); and
3. Soil sampling in areas of historic surface water runoff (Section 7.3.3).

A review of recently collected site-wide data including the ongoing site-wide Geologic Characterization Study that may be pertinent to OU11, will be conducted prior to commencing any field work mentioned above. All field activities conducted under the OU11 Work Plan will follow the requirements in the Site-Wide Interim Plan for Prevention of Contamination Dispersion (IPPCD) or Plan for Prevention of Contaminant Dispersion (PPCD) and the Site-Wide Health and Safety Plan.

7.3.1 OU-Wide Radiological Survey and Surficial Sampling Program

The West Spray Field was designed to enhance the evaporation of wastewater from the Solar Evaporation Ponds, 207-B North and 207-B Center. Wastewaters may have contained low concentrations of radionuclides which may have been deposited by the spraying. Previous aerial gamma-ray surveys have not shown any man made radionuclide activity to be present (Boyns, 1982 and 1990). Those surveys showed no increase in exposure above that which is expected from natural sources. It is recommended that a limited number of ground-based in-situ measurements be done utilizing a high purity germanium (HPGe) gamma-ray detector system, potentially augmented with a limited number of soil samples.

Sampling strategies for the HPGe detector-based system shall be computer modeled using previously collected data to ensure proper sampling densities of the affected land mass. The modeling shall be based on a 150 foot (46 meter) grid which allows for 100 percent coverage of the West Spray Field area using the HPGe system. This grid spacing is also optimum for detecting americium, a relatively low-energy gamma emitter and plutonium daughter, using the HPGe system. Sampling shall concentrate at the actual spray areas to verify presence or absence of contamination. The results of the modeling shall be presented as a map with sampling locations shown and in tabular form with sample number, Colorado Grid Coordinates as well as latitude, longitude, and elevation. A CDRR explaining sample locations and rational will be submitted to the regulatory agencies for approval prior to implementing the in-situ sampling.

Survey crews shall use a global positioning system (GPS) to locate sampling sites presented by the computer modeling. The HPGe detector(s) shall normally be positioned 25 feet (7.5 meters) above the ground level (AGL) during the measurements. A written log shall be maintained in addition to an electronic media log that documents each measurement as it is taken. The data shall be analyzed at the completion of the measurement to provide 'real time' results and quality assurance. The collected data shall be stored on electronic media providing a permanent record. Measurement technique shall follow an EMD-OP currently under development. The EMD-OP will be submitted to the regulatory agencies for approval prior to implementing the survey.

Soil samples may be taken along transects at locations that correspond to ground-based in-situ samples to provide information regarding the presence of non-gamma emitting radionuclides and radionuclides at low concentrations. At least two types of soil samples may be collected at each sample site: (1) vertical profile samples and (2) grab samples. A third sample may be collected and archived for future evaluation pending the results of the in-situ survey. Specific sampling locations shall be based on computer modeling and in-situ measurements. Sampling crews shall locate the sample site with GPS and shall maintain a log documenting the soil sample and its location. Sampling technique shall follow an EMD-OP currently under development. The EMD-OP will be submitted to the regulatory agencies for approval prior to implementation of the sampling.

In the event that the in-situ results do not confirm the results of previous aerial surveys then sampling strategies may be modified to ensure adequate site characterization.

All modifications will be submitted to the regulatory agencies for approval as an addendum to this Work Plan.

Surficial Sampling

Soil data will be collected using a systematic grid sampling approach. This approach is beneficial in identifying unknown hot spots and providing unbiased estimates of chemical occurrence and concentration (EPA, 1990). A grid with a sampling distance of 300 feet will be used to guide surficial soil sampling in OU11 and the immediate perimeter. The 300-foot spacing provides a screening mechanism for potential contaminants within the large area of OU11. The surface sediment sampling along surface water runoff channels will augment characterization of the non-source areas. Sediment sampling is discussed in more detail in Section 7.3.3.

The surficial soil samples will be analyzed for metals, inorganics, and nitrates. These analyses, in conjunction with the in-situ radiation survey and associated soil sampling results will be evaluated against background levels to determine the presence or absence of contamination and the degree of spatial variation of contaminant parameters in the surficial soils. If it is determined that contaminants are present, subsequent soil sampling may be required to delineate the extent of contamination. A denser sampling grid within areas of interest would provide the necessary detail to fill in data gaps and prevent false positive (Type I) or false negative (Type II) errors in data interpretation resulting in inaccurate risk assessment conclusions and thus inappropriate remedy selection. If the subsequent sampling activity is necessary, an addendum to this Work Plan will be submitted to the regulatory agencies for approval prior to implementation of field work.

The initial sampling grid is to be aligned parallel to the spray application lines in order to maximize the sampling points in the source areas. The grid sampling layout is shown in Figure 7-1 which indicates that approximately 75 samples will be collected in OU11.

Prior to conducting the survey, the survey points will be established by using an electronic distance meter with an electronic digital theodolite. Stakes will be left to mark each surveyed location. Surveyed locations will be marked with a grid location and the Colorado Grid coordinates. If a structure or other obstruction makes conducting measurements at the node difficult, the survey location will be moved to the closest location where readings may be taken. Field team members will coordinate with ongoing operations personnel to ensure that stakes or flagging used to identify sampling locations are not moved or damaged by ongoing RFP activities prior to surveying.

Each grid node will be identified with a unique station number using alphabetical and numerical grid identifiers such as A-1 or B-3 where letters are assigned to rows and numbers assigned to columns. Any survey readings taken at non-standard grid locations will also be given a unique identifier.

Surficial soil samples will be collected in accordance with the CDH soil sampling protocol described in EMD.OP GT.8 and CDN GT.8-91-1. Two one-meter square areas located one meter apart will be established at each surficial sampling location. If asphalt or other barriers prevent the collection of a surficial sample, the location will be moved to the closest accessible location. From the two square meters, a minimum of five soil samples will be collected from each of the corners and the center of each square meter. Additional subsamples may be collected in order to obtain a sufficient sample volume for analysis. Samples will be collected to a one inch depth with either a plug type sampler, or a stainless steel scoop. The subsamples will be composited in a large stainless steel bowl or pan and stirred with a stainless steel scoop or spoon. Sample handling will be conducted in accordance with EMD-OP FO.13, Containerizing, Preserving, Handling, and Shipping Soil and Water Samples. Sampling equipment will be decontaminated between individual sampling points in accordance with EMD-OP FO.3, General Equipment Decontamination. Documentation of the surficial soil sampling activity at the West Spray Field will be in accordance with EMD-OP GT.8.

7.3.2 Soil Physical and Chemical Characterization

Characterization of subsurface materials is necessary to determine the presence or absence of contaminants and their vertical extent. The subsurface soil physical and chemical properties will be accomplished by collecting soil samples in test pits. Characterization of soil properties will include defining the geotechnical parameters such as soil moisture, soil type, texture and particle characteristics and the chemical parameters to determine the presence or absence of contamination. If contamination is determined to be present in the test pits and further investigation is needed, boreholes will be drilled in order to characterize the subsurface materials to the saturated zone. A work plan and rationale for borehole investigations will be submitted as an addendum to this Work Plan should it be necessary.

Investigation using test pits permits collection of geotechnical data and samples over a larger cross-sectional area than boreholes and consequently can provide a better representation of site conditions. Test pit excavation will allow collection of soil profile samples to evaluate the nature and extent, and fate and transport of contaminants in the shallow subsurface where the primary contaminants of concern for the West Spray Field are most likely to collect based on their chemical properties.

Sixteen proposed test pits are located to best evaluate the area(s) of the direct spray application, source pipeline, surface water runoff, geologic concern and where data gaps exist. The location rationale and sampling criteria for each test pit location are provided in Table 7-2. Test pits are listed in Table 7-2 from north to south and west to east as shown on Figure 7-2.

Test pits will be excavated in accordance with EMD-OP GT.7 using a backhoe such that one pit wall is dug in benches in order to minimize cross contamination along the pit wall. Test pits will be excavated to a depth of 4 feet to expose the A, B, and C soil horizons and to allow geologic mapping of the test pit and subsequent soil sampling. If the C soil horizon is not exposed at the 4 foot depth, the test pit will be excavated one foot deeper. Soil horizons are described in Section 2.2.4.2.

Within each test pit, the subsurface materials will be characterized in accordance with EMD-OP GT.1. Additionally, the test pits will be screened for potential contamination after excavation with a photoionization detector and a Ludlam model 12-1A alpha monitor with an air proportional probe, or equivalent, and a gamma/beta detector for health and safety purposes.

One composite soil sample will be collected in soil horizons A, B and C each to evaluate the nature and extent of contamination within each horizon. The procedure is to collect a composite sample over the upper most six inches of each soil horizon starting at the deepest part of the test pit to prevent cross contamination between sample intervals. The depth of the sample will be measured from the ground surface and recorded. A total of 48 test pit soil samples will be collected.

Upon completion of sampling and data collection, the test pits will be backfilled following the procedures outlined in EMD-OP GT.7.

If contamination is detected in the vadose zone soils, then borehole drilling will be required to further characterize the contaminant source. Borehole locations will be determined based on evaluation of data collected from all sampling tasks identified in this Work Plan. A detailed field sampling plan for borehole drilling and sampling will be submitted, as an addendum to the OU11 Work Plan, to the regulatory agencies for approval prior drilling. If soil samples collected from within the boreholes are found to be contaminated, the boreholes may be completed as groundwater monitoring wells for the Phase II RFI/RI. Screened intervals will be based on water level fluctuations determined from existing monitoring wells within the West Spray Field. Soil moisture using ASTM D2216 will be performed at 10 foot intervals down to the water table for each borehole.

7.3.3 Sediment Sampling in Areas of Historic Spray Application Areas and Surface Water Runoff

Sediment samples from areas of historic spray application will be analyzed for potential contamination. Sample procedures will follow those outlined in EMD-OP SW.6. Sample locations are shown on Figure 7-2. The sample locations may be modified based on field evaluation of runoff channels including amount of soil accumulation, vegetative cover, and results of the radiation survey and surficial soil sampling. Sample locations are based on historic surface water runoff areas within the West Spray Field boundaries and where the runoff breached bermed areas along the northern IHSS boundary as identified in aerial photographs. The terrestrial sample locations identified in the Environmental Evaluation (Section 9.0) are coordinated with the sediment sample locations for comparative analyses. There are 33 sediment sample locations within and north of the West Spray Field boundaries. Sample locations are shown on Figure 7-2.

Each sediment sample will consist of a maximum one-foot composite sample taken to the depth of the first gravel layer below the sediment. If the sediment is thicker than one foot, a second composite sample will be collected from one to two feet. The sediment samples will be geologically logged in accordance with EMD-OP GT.1.

7.4 SAMPLE ANALYSIS

This section describes the sample handling procedures and analytical program for samples collected during the Phase I investigation. This section also includes discussions of sample designation, analytical requirements, sample containers and preservation, and sample handling and documentation.

7.4.1 Sample Designation

All sample designations generated for the RFI/RI will conform to the input requirements of RFEDs, as described in EMD-OP FO.14A. Each sample designation will contain a nine-character sample number consisting of a two-letter prefix identifying the media samples (SB for soil boring, SS for surficial soils, etc.), a unique five-digit number, and a two letter suffix identifying the contractor. One sample number will be required for each sample generated including QC samples. In this manner, 99,999 unique sample numbers are available for each sample media for each contractor that contributes sample data to the database. Boring numbers will be developed independently of the sample number for a given boring. These sample numbering procedures are consistent with the RFP site-wide QAPjP.

7.4.2 Analytical Requirements

The analytical suites for surficial soil samples and unconsolidated material samples were developed based on the types of contaminants detected historically in the waste source from Solar Evaporation Ponds 207-B North and 207-B Center. The waste analyses are summarized in Section 2.0. The geochemical behavior of the contaminants was also considered in the selection of the analytical suites. Specific analytes in the above groups and their CLP detection/quantitation limits are listed in Table 7-2. These analytes and limits address the chemicals that previously were detected in the pond liquids, and the previous samples collected from OU11.

Soil samples from the vadose zone collected during the West Spray Field Phase I RFI/RI will be analyzed for all of the following chemical and radionuclide parameters or parameter groups:

- Target Analyte List (TAL) Metals;
- Uranium 233/234, 235, 236 and 238;
- Plutonium and Americium;
- Gross Alpha and Gross Beta;
- Tritium;
- TCL volatile organics;
- TCL semivolatile organics; and
- Inorganics.

Because of the volatile nature of TCL volatiles and semivolatiles and the elapsed time since the last spray application, surficial soil and sediment samples will be analyzed for only a subset of these parameter groups. For the sediment samples, the parameter group includes:

- Inorganics;
- TAL Metals;
- Uranium 233/234, 235, 236 and 238;
- Plutonium and Americium;

- Gross alpha and gross beta; and
- Tritium.

The surficial soil samples will be analyzed for the same parameters except for radionuclides. Radionuclide data will be collected under the radiation survey soil sampling task. The radionuclide parameters analyzed under that task include at a minimum, those listed above.

7.4.3 Sample Containers and Preservation

Sample volume requirements, preservation techniques, holding times, and container material requirements are dictated by the media being sampled and by the analyses to be performed. The soil matrices to be analyzed will include surficial soils and unconsolidated materials (see Tab le 7-3). Additional specific guidance on the appropriate use of containers and preservatives is provided in EMD-OP FO.13, Containerizing, Preserving, Handling, and Shipping of Soil and Waste Samples. Information on preparing samples specifically for radiological analysis is provided in EMD-OP F0.18.

7.4.4 Sample Handling and Documentation

Sample control and documentation is necessary to ensure the defensibility of data and to verify the quality and quantity of work performed in the field. Accountable documents include logbooks, data collection forms, sample labels or tags, chain-of-custody forms, photographs, and analytical records and reports. Specific guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in FO.13.

7.5 DATA MANAGEMENT AND REPORTING REQUIREMENTS

The field data collected during the various investigations discussed in Section 7-3 will be documented as outlined in the specific EMD-OPs cited. Field data will be managed according to EMD-OP F0.2.

Field data will be input to RFEDs using a remote data entry module supplied by EG&G. Data will be entered on a 3.5-inch computer diskette and will be delivered to EG&G on a timely basis. A hard copy report will be generated from the module for contractor use. Procedures for data quality control, verification, entry into RFEDS, archiving and security will follow EMD-OP FO.14.

A sample tracking spreadsheet will be maintained by the contractor for use in tracking sample collection and shipment. EG&G will supply the spreadsheet format and will stipulate timely reporting of information. These data will also be delivered to EG&G on 3.5-inch computer diskettes. Computer hardware and software requirements for contractors using government-supplied equipment will be supplied by EG&G. Computer and data security measures will also follow acceptable procedures outlined by EG&G.

7.6 FIELD QC PROCEDURES

Sample quality will be controlled by following the prescribed EMD-OPs or accepted methods for sample collection, sample shipment, equipment use, equipment decontamination, and equipment calibration as discussed previously in the FSP. These procedures provide the best methods for collection of representative samples. In addition, three types of field quality control (QC) samples will be collected: sample duplicates, field preservation blanks, and equipment rinsate blanks. An additional QC sample, a trip blank, will be prepared when needed by the laboratory performing the analyses.

The analytical results obtained for these samples will be used by the ER project manager to assess the quality of the field sampling effort. The types of field QC samples to be collected and their application are discussed below. The frequency with which QC samples will be collected and analyzed is provided in Table 7-4.

Duplicate samples will be collected by the sampling team for use as a relative measure of the precision of the sample collection process. These samples will be collected at the same time, using the same procedures and equipment, and in the same types of containers as required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples. Duplicate samples will only be collected during groundwater sampling.

Field preservation blanks of distilled water, preserved according to the preservation requirements (Section 7.4.3), will be prepared by the sampling team and will be used to provide an indication of any contamination introduced during field sample preparation. As indicated in Table 7-4, these QC samples are applicable only to samples requiring chemical preservation.

Equipment rinsate blanks will be collected from final decontamination rinsate to evaluate the success of the field sampling team's decontamination efforts on non-dedicated sampling equipment. Equipment blanks are obtained by rinsing cleaned equipment with distilled water prior to sample collection. The rinsate is collected and placed in the appropriate sample containers. Equipment rinsate blanks are applicable to all analyses for water and soil samples, as indicated in Table 7-4.

Trip blanks consisting of distilled water will be prepared by the laboratory technician and will accompany each shipment of samples for volatile organic analysis. Trip blanks will be stored with the group of samples with which they are associated. Analysis of the trip blank will indicate migration of volatile organics or any problems associated with sample shipment, handling, or storage. Information from the trip blanks will be used in conjunction with air monitoring data and other information to assess the influence of ongoing waste operations on the quality of data collected.

Procedures for monitoring field QC are provided in the site wide QAPP. The collection of QC samples will be documented on the proper soil or water sample collection logs per EMD-OPs GT.2 and GT.8 and DCN GT.8-91-1.

7.7 AIR MONITORING PROCEDURES

Air monitoring will be performed during field activities to ensure that quality data are obtained during sampling and that all sampling activities comply with the Interim Plan for Prevention of Contaminant Dispersion (IPPCD) (EG&G, 1991h). Air quality monitoring will be performed in accordance with EMD-OPs presently being developed by EG&G.

Air quality monitoring requirements for activities such as borehole drilling where there is a significant potential for producing appreciable quantities of suspended particulates include the following.

- Site perimeter and community Radiological Ambient Air Monitoring Program (RAAMP) monitoring.
- Local monitoring of Respirable Suspended Particulates (RSP) at individual activity work sites shall be conducted using a TSI "Piezobalance" Model 3500 Respirable Aerosol Mass Monitor, a real-time instrument. Local RSP measurements will be

used to guide the project Manager's evaluation of the potential hazards associated with activity-related emissions. The threshold RSP concentration for curtailing intrusive activities will be 6.0 milligrams/cubic meter (mg/m^3).

° Additional worker health and safety monitoring as required by the Site-Specific Health and Safety Plan (SSH&SP).

TABLE 7-1
SUMMARY OF FIELD SAMPLING ACTIVITIES FOR OU11

Field Activity	Purpose	Location	Estimated No. of Data Collection Points	Method	Analysis	Rational	Conceptual Model Pathway Address
Review new data	- Evaluate/incorporate new data	NA	NA	- Site-wide ER programs - Other OU RFI/RI activities	NA	Coordination of ER efforts, and optimizes data collection and interpretation efforts	NA
Radiation Survey	- Evaluate health and safety requirements - Identify hot spots - Screening for surficial soil, sediment and vadose zone sampling	West Spray Field area	To be determined	- Ground-based gamma survey using high purity germanium crystal detector (EMD-OP under development) - Soil sampling	Gamma emitting isotopes, and back calculation for plutonium; chemical analyses of U, Pu, Am, gross α, gross β, tritium	Characterizes dispersion of contaminants over West Spray Field area by spray activities, wind and, surface water runoff	Surface soils
Review existing and on-going geologic studies	- Delineate subsurface features which may potentially impact contaminant migration	Site wide	NA	NA	NA	Subsurface characterization over large area which assists hydrogeologic characterization and pathway analysis	Ground water, vadose zone
Surficial Soil Sampling	- Characterize surficial soil contamination	West Spray Field area	75	- EMD-OP GT.8; CDH protocol, DCN.8-91-1	Nitrates, TAL metals, and inorganics	Provides data for pathway analysis, environmental evaluation and evaluation of remedial alternatives	Surficial soils
Test Pit Samples	- Characterize physical/chemical properties of soils - Characterize soil contamination	Test pits in spray application areas, surface water runoff channels, along pipeline, areas of geologic concern and data gaps, Samples collected from A, B, and C soil horizons	48	- EMD-OP GT.7 - EMD-OP GT.1 - EMD-OP GT.2	Nitrates, TAL metals, U, Pu, Am, gross α, gross β, tritium, TCL volatile organics, TCL semi volatile organics, and inorganics	Characterization of subsurface materials for fate and transport, pathway analyses, environmental evaluation and evaluation of remedial alternatives	Vadose zone
*Borehole Samples (*if subsurface samples are contaminated)	- Characterize physical chemical properties of soils - Characterize soil contamination - Determine need for ground water monitoring	To be determined pending subsurface soil sampling results	To be determined pending vadose zone sampling results	EMD-OP GT.1 EMD-OP GT.2 EMD-OP GT.5 EMD-OP GT.10 EMD-OP FO.1 EMD-OP FO.3 EMD-OP FO.4 EMD-OP FO.8 EMD-OP FO.10 EMD-OP FO.12 (ASTM D-2216)	Nitrates, TAL metals, U, Pu, Am, gross α, gross β, tritium, TCL volatile organics, TCL semivolatile organics, inorganics	Characterization of subsurface soils for nature and extent, fate and transport, pathway analyses, and evaluation of remedial alternatives	Vadose zone

TABLE 7-1
SUMMARY OF FIELD SAMPLING ACTIVITIES FOR OU11

Field Activity	Purpose	Location	Estimated No. of Data Collection Points	Method	Analysis	Rational	Conceptual Model Pathway Address
Sediment Samples	- Characterize contamination in surface water runoff channels	Along surface water runoff channels	16	EMD-OP SW.6 EMD-OP GT.1	Nitrates, TAL metals, U, Pu, Am, gross α, gross β, tritium and inorganics	Characterization of sediment in runoff channels for nature and extent, pathway analyses, environment evaluation and evaluation of remedial alternatives	Sediment and surficial soils
Implementation of (Interim) Plan for Prevention of Contaminant Dispersion (PPCD)	- To prevent contaminant dispersion	All areas of land disturbance caused by field activities	NA	As outlined in PPCD	NA	Protection of human health and safety	NA

* EMD-OPs required for sample handling; equipment decontamination, air monitoring and dust control

EMD-OP FO.1 Air monitoring and dust control
EMD-OP FO.3 General equipment decontamination
EMD-OP FO.7 Handling of decontamination water and wash water
EMD-OP FO.13 Containerization, preserving, handling and shipping of soil and water samples
EMD-OP FO.14 Field data management
EMD-OP FO.18 Environmental sample radioactivity content screening

**EMD-OPs were previously SOPs.

TABLE 7-2

TEST PIT LOCATION CRITERIA

Test Pit Location	Spray Application Quantity	Location Rationale	Potential Contaminants in the Subsurface
Spray Application Area 1: west section 1	190 in. of water column (max)	Characterization of north end of spray line; west end of pipe line; and fill data gap.	metals radionuclides nitrates VOCs
2		Characterization of south end of spray line; west end of surface water drainage channel; and fill data gap.	
mid section 1	190 in. of water column (max)	Characterization of north half spray line; surface water drainage channel; supplement monitoring well data; fill data gap.	
2		Characterization of south half of spray line; surface water drainage channel; and fill data gap.	

TABLE 7-2 (continued)

TEST PIT LOCATION CRITERIA

Test Pit Location	Spray Application Quantity	Location Rationale	Potential Contaminants in the Subsurface
east section 1	190 in. of water column (max)	Characterization of north end of spray line; west end of pipe line; and fill data gap.	
2		Characterization of middle section of spray line; surface water drainage channel; and fill data gap.	
3		Characterization of south end of spray line; west end of surface water drainage channel; supplement monitoring well data; and fill data gap.	
Spray Application Area 2:	150 in. of water column (max)	Characterization of mid section surface water drainage channel; supplement monitoring well data.	metals radionuclides nitrates VOCs
2		Characterization of south end of area; surface water drainage channel; and fill data gap.	

TABLE 7-2 (continued)

TEST PIT LOCATION CRITERIA

Test Pit Location	Spray Application Quantity	Location Rationale	Potential Contaminants in the Subsurface
Spray Application Area 3:	150 in. of water column (max)	Characterization of west end area; and fill data gap.	metals radionuclides nitrates VOCs
Surface water Runoff Area: west section 1 2 3 4	NA	Characterization of source pipeline; north end of area; and fill data gap. Characterize soils overlying possible subsurface paleochannel subsurface; and fill data gap. Characterize mid section of area; and fill surface water drainage channel; data gap. Characterize south end of area; and fill data gap.	metals radionuclides nitrates VOCs

TABLE 7-2 (continued)

TEST PIT LOCATION CRITERIA

Test Pit Location	Spray Application Quantity	Location Rationale	Potential Contaminants in the Subsurface
east section 1		Characterize surface water drainage channel; and fill data gap;	
2		Supplement monitoring well data; and fill data gap.	

TABLE 7-3
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

	Detection Limits*	
Target Analyte List - Metals	Water ($\mu g/l$)	Soil/Sediment (mg/kg)
Aluminum	200	40
Antimony	60	12
Arsenic	10	2
Barium	200	40
Beryllium	5	1.0
Cadmium	5	1.0
Calcium	5000	2000
Cesium	1000	200
Chromium	10	2.0
Cobalt	50	10
Copper	25	5.0
Cyanide	10	10
Iron	100	20
Lead	5	1.0
Lithium	100	20
Magnesium	5000	2000
Maganese	15	3.0
Mercury	0.2	0.2
Molybdenum	200	40
Nickel	40	8.0
Potassium	5000	2000
Selenium	5	1.0
Silver	10	2.0
Sodium	5000	2000
Strontium	200	40
Thallium	10	2.0
Tin	200	40
Vanadium	50	10.0
Zinc	20	4.0

TABLE 7-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Target Compounds List - Volatiles	Quantitation Limits* Water $\mu g/l$)	Soil/Sediment ($\mu g/kg$)
Chloromethane	10	10
Bromomethane	10	10
Vinyl Chloride	10**	10
Chloroethane	10	10
Methylene Chloride	5	5
Acetone	10	10
Carbon Disulfide	5	5
1,1-Dichloroethene	5	5
1,1-Dichloroethane	5	5
trans 1,2-Dichloroethene	5	5
Chloroform	5	5
1,2-Dichloroethane	5	5
2-Butanone	10	10
1,1,1-Trichloroethane	5	5
Carbon Tetrachloride	5	5
Vinyl Acetate	10	10
Bromodichloromethane	5	5
1,1,2,2-Tetrachloroethane	5	5
1,2-Dichloropropane	5	5
trans-1,3-Dichloropropene	5	5
Trichloroethene	5	5
Dibromochloromethane	5	5
1,1,2-Trichloroethane	5	5
Benzene	5	5
cis-1,3-Dichloropropene	5	5
Bromoform	5	5
2-Hexanone	10	10
4-Methyl-2-penatone	10	10
Tetrachloroethene	5	5
Toluene	5	5
Chlorobenzene	5	5
Ethyl Benzene	5	5
Styrene	5	5
Total Zylenes	5	5

TABLE 7-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Semivolatiles	Quantitation Limits* Water μg/l	Soil/Sediment μg/Kg
Phenol	10**	330
bis(2-Chloroethyl)ether	10**	330
2-Chlorophenol	10**	330
1,3-Dichlorobenzene	10	330
1,4-Dichlorobenzene	10	330
Benzyl alcohol	10	330
1,2-Dichlorobenzene	10	330
2-Methylphenol	10	330
bis(2-Chloroisopropyl)ether	10	330
4-Methylphenol	10	330
N-Nitroso-di-n-propylamine	10	330
Hexachloroethane	10	330
Nitrobenzene	10**	330
Isophorone	10	330
2-Nitrophenol	10	330
2,4-Dimethylphenol	10	330
Benzoic acid	50	1600
bis(2-Chloroethoxy)methane	10	330
2,4-Dichlorophenol	10	330
1,2,4-Trichlorobenzene	10	330
Naphthalene	10	330
4-Chloroaniline	10	330
Hexachlorobutadiene	10	330
4-Chloro-3-methylphenol(para-chloro-meta-cresol)	10	330
2-Methylnaphthalene	10	330
Hexachlorocyclopentadiene	10	330
2,4,6-Trichlorophenol	10	330
2,4,5-Trichlorophenol	50	1600
2-Chloronapthalene	10	330
2-Nitroaniline	50	1600
Dimethylphthalate	10	330
Acenaphthylene	10	330
2,6-Dinitrotoluene	10	330
3-Nitroaniline	50	1600
Acenaphthene	10	330

TABLE 7-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

2,4-Dinitrophenol	50	1600
4-Nitrophenol	50	1600
Dibenzofuran	10	330
2,4-Dinitrotoluene	10	330
Diethylphthalate	10	330
4-Chlorophenyl-phenyl ether	10	330
Fluorene	10	330
4-Nitroaniline	50	1600
4,6-Dinitro-2-methylphenol	50	1600
N-nitrosodiphenylamine	10	330
4,-Bromophenyl-phenylether	10	330
Hexachlorobenzene	10**	330
Pentachlorophenol	50	1600
Phenanthrene	10	330
Anthracene	10	330
Di-n-butylphthalate	10	330
Fluoranthene	10	330
Pyrene	10	330
Butylbenzylphthalate	10	330
3,3'-Dichlorobenzidine	20**	660
Benzo(a)anthacene	10	330
Chrysene	10	330
bis(2-Ethylhexyl)phthalate	10	330
Di-n-octylphthalate	10	330
Benzo(b)fluoranthene	10	330
Benzo(k)fluoranthene	10	330
Benzo(a)pyrene	10	330
Ideno(1,2,3-cd)pyrene	10	330
Dibenz(a,h)anthracene	10	330
Benzo(g,h,i)perylene	10	330

TABLE 7-3 (continued)
SOIL, SEDIMENT, AND WATER
SAMPLING PARAMETERS AND DETECTION/QUANTITATION LIMITS

Radionuclides	Quantitation Limits* Required Detection Limits* Water (pCi/l)	Soil/Sediment (pCi/g)
Gross Alpha	2	4 dry
Gross Beta	4	10 dry
Uranium 233+234, 235, and 238 (each species)	0.6	0.3 dry
Americium 241	0.01	0.02 dry
Plutonium 239+240	0.01	0.03 dry
Tritium	400	400 (pCi/ml)

*Detection and quantitation limits are highly matrix dependent. The limits listed here are the minimum achievable under ideal conditions. Actual limits may be higher.

**The laboratory Practical Quantification Limits (PQLs) for these analytes exceed ARARs.

TABLE 7-4
FIELD QC SAMPLE FREQUENCY

Sample Type	Type of Analysis	Media	
		Solids	Liquids
Duplicates	Organics	1/10	1/10
	Inorganics	1/10	1/10
	Radionuclides	1/10	1/10
Field Preservation Blanks	Organics	NA	NA
	Inorganics	NA	1/20
	Radionuclides	NA	1/20
Equipment Blanks	Organics	1/20	1/20
	Inorganics	1/20	1/20
	Radionuclides	1/20	1/20
Trip Blanks	Organics	NR	1/20
	Inorganics	NR	NR
	Radionuclides	NR	NR

NA = Not Applicable
NR = Not Required
1/10 = one QC sample per ten samples collected

8.0 BASELINE HUMAN HEALTH RISK ASSESSMENT PLAN

8.1 OVERVIEW

Section 300.430(d) of the National Contingency Plan (Federal Register, March 8, 1990, p. 8709) states that as part of a remedial investigation, a Baseline Risk Assessment must be conducted. The purpose of the Baseline Risk Assessment is to provide an estimate of current or potential risks to human health and the environment that may result from releases of hazardous substances from a site in the absence of any remedial action. Results of a Baseline Risk Assessment are also used to determine whether remedial actions are warranted and, if so, the associated cleanup levels necessary to protect human health and the environment.

In addition to the requirements stated above, the Rocky Flats Plant IAG requires that a Baseline Risk Assessment be prepared for the West Spray Field - OU11 as part of the Phase I RFI/RI report. The IAG specifies that technical memoranda pertaining to the OU11 Baseline Risk Assessment will be developed. The purpose of the memoranda is to provide an initial evaluation and outline of several essential components of the Baseline Risk Assessment for OU11. Four separate memoranda will be developed for OU11 which will address the following:

- The indicator chemicals to be evaluated;
- Potential and reasonable use exposure scenarios;
- Fate and transport models that will be utilized; and
- Toxicological and epidemiological studies that will be utilized to perform the toxicity assessment.

The contents of the individual memoranda, as outlined in the IAG, are discussed within Sections 8.2, 8.3, and 8.4 of this Work Plan.

Both a Human Health Evaluation and an Environmental Evaluation must be completed as part of the Baseline Risk Assessment. The Human Health Evaluation portion of the Work Plan is described in this section while the Environmental Evaluation portion is discussed separately in Section 9.0.

The four major components of the Human Health portion of the Baseline Risk Assessment include:

- Identification and description of contaminants of concern;
- Exposure assessment;
- Toxicity assessment; and
- Risk characterization.

A fifth significant component of the Baseline Risk Assessment is the uncertainty analysis. The uncertainty analysis provides a qualitative and/or quantitative analysis of factors that affect the risk assessment. In addition, several crucial subcomponents of the Human Health Risk Assessment include the identification of exposure pathways, selecting appropriate exposure scenarios (including potential future use), and establishing demographic factors which could affect exposure. All of the components of the Human Health Baseline Risk Assessment are described in detail within the following subsections of the Work Plan.

The Human Health Risk Assessment objective is to identify and assess potential human health risks resulting from exposure to site contaminants present in various environmental media. The major tasks to be completed as part of the Human Health Risk Assessment include the following:

- Assess the toxicity of the hazardous substances present at the West Spray Field, including radionuclides, based upon the most current toxicological data available. Additionally, develop a representative characterization of the types, concentrations, and distribution of contaminants present in relevant media.

- Evaluate fate and transport mechanisms within specific environmental media and evaluate contaminant behavior. Definition of these mechanisms is necessary in deriving exposure point concentrations. Where appropriate, inter-media fate and transport is also evaluated.

- Identify potential human receptors and characterize demographic factors which impact exposure.

- Identify potential exposure scenarios, including evaluation of an appropriate future use scenario. In addition, quantify the frequency, duration, and dose of exposure to the contaminants of concern.

- Define the extent of any identified impact or threat, and calculate the chance of such an impact or threat of occurring (i.e., calculate the incremental risk or hazard index).

- Conduct a thorough qualitative and/or quantitative analysis of computed risks and determine the associated level(s) of uncertainty.

Figure 8-1 illustrates the basic Human Health Risk Assessment components and tasks to be completed as described above. Human Health Risk Assessment results will be used to determine whether or not remedial actions are warranted at OU11 and, if so, the associated cleanup levels necessary to protect human health.

The Human Health Risk Assessment for OU11 will be performed in accordance with U.S. EPA and other guidance documents listed in Table 8-1. The documents listed constitute the most recent U.S. EPA guidance in public health risk assessment. The listed manuals are intended as guidelines only and the U.S. EPA states that considerable professional judgement should be used in the application of these materials. In addition to available national U.S. EPA guidance, supplemental U.S. EPA, Region VIII risk assessment guidance will be used, if applicable.

The focus of the risk assessment for OU11 will be to produce a realistic analysis of exposure and health risk. The Human Health Risk Assessment Plan outlined in the following subsections is applicable to the entire RFI/RI process for OU11. Although the Phase I Work Plan objectives focus on the characterization of the source of contamination, information obtained during this portion of the investigation will also be applied to the overall risk assessment process. As a result, an overall Human Health Risk Assessment can be developed in pieces as the investigation progresses from definition of the source (Phase I) to characterization of the nature and extent of contamination (Phase II).

8.2 DATA COLLECTION AND DATA EVALUATION

The data collection and evaluation process used in identifying source-related contaminants at OU11 is discussed in the subsections below (U.S. EPA, 1989b). This process is divided into several steps including: summarizing and characterizing existing site data that is relevant to performing the Human Health Risk Assessment, collecting new site data to fill gaps (as identified in Section 4.0) and finally, selecting the contaminants of concern (COCs). The COCs are selected based upon several prioritizing criteria including contaminant toxicity, bioavailability, duration, and persistence; the frequency of contaminant detection; the concentrations present; and the likelihood of exposure actually occurring. The contaminants of concern are selected from the entire suite of chemicals and other constituents, such as metals or radionuclides, that are present at the site.

8.2.1 Data Collection

The first phase in data collection and evaluation is to summarize all available data. The existing body of contaminant data for OU11 is discussed in Section 2.3, Nature of Contamination. Section 2.3 summarizes information regarding known historical releases at OU11, previous soil sampling activities and results, and background soil quality. Surface water, sediment, and groundwater data are also summarized in Section 2.3.

In addition to existing contaminant data, other relevant information that is collected includes:

- A site description;
- Sample design with sampling locations;
- Analytical methods and detection limits;
- Analytical results for each sample, including laboratory qualifiers;
- Sample quantitation limits and/or detection limits for non-detects; and
- Field conditions.

An initial description of OU11 has already been developed and is provided in Section 2.2. Previous sampling events, sample locations, and existing results are described in Section 2.3. Information regarding analytical methods, detection limits, analytical qualifiers for the existing database, and field conditions for existing data have been preliminarily compiled and evaluated and are described in Section 2.3. A more thorough compilation of this information will be necessary as part of the Phase I RFI/RI.

The second phase of data collection is the compilation of new data gathered as part of the Phase I RFI/RI. The new data to be collected are described in detail in Section 7.0, Field Sampling Plan. As new data are collected, they will be assembled in a format which facilitates their evaluation in the Human Health Risk Assessment.

Following the compilation of all existing and newly collected data, those data that are specifically relevant to performing the Human Health Risk Assessment are selected. This selection process is discussed in detail in the following data evaluation section.

8.2.2 Data Useability

The useability of existing and newly collected Phase I RFI/RI data will be evaluated in accordance with the following steps (U.S. EPA, 1990a):

- Assess data completeness;
- Assess the appropriateness and completeness of data sources;
- Assess the appropriateness of analytical methods and detection limits;
- Determine whether or not U.S. EPA data validation protocols were applied;
- Assess sampling data quality indicators for their completeness, comparability, representativeness, precision, and accuracy; and

- Assess analytical data quality indicators (such as spike recoveries, duplicates, and blanks) for completeness, comparability, representativeness, precision, and accuracy.

Details regarding the above outlined steps are contained within the RFP Site-wide Quality Assurance Project Plan (QAPjP). Information regarding the quality of data to be used in the Baseline Risk Assessment, the percentage of data that will undergo validation, and the U.S. EPA Contract Laboratory Plan (CLP) procedures that will be employed in sample analysis are outlined in the QAPjP. In addition, the RFP "General Radiochemistry and Routine Analytical Services Protocol" (EG&G, 1991e) (GRRASP) addresses laboratory quality assurance and quality control procedures that will be applied to radionuclide analyses. The existing data for the West Spray Field, collected from 1989 to the present, has undergone validation, where as, the older has not been validated.

A preliminary data useability analysis of existing WSF data is discussed in Section 2.3, Nature of Contamination and in Section 4.0, Data Needs and Data Quality Objectives. As is presented in Sections 2.3 and 4.0, the majority of the existing data is suitable primarily for qualitative use. In general, it was concluded that new data is needed for defining contaminant transport media including surface water, sediment, the vadose zone, groundwater, and biota.

Following completion of the RFI/RI data collection, analysis, and validation, new data will be evaluated to determine if they support historical trends. Where new data and existing data appear compatible, the existing data will undergo re-evaluation to identify those that could be used quantitatively in conjunction with new data.

Part of the data evaluation will also include generating an appropriate summary process and format. This will involve identifying statistical summary techniques that consider spatial and temporal data distributions, determining if arithmetic or geometric means are appropriate, and determining the appropriate method for dealing with non-detected values and qualified data. The data summary will include:

- The frequency of detection (number of positive detects/number of analyses) for each compound and sample location;
- The minimum and maximum reported concentrations for each compound at each sample location; and
- The overall range of concentrations (the maximum and minimum) for each compound over the entire OU11 study area.

Any compounds identified during laboratory analysis that appear below quantitation levels are distinguished as tentatively identified compounds (TICs) and will also be evaluated relative to their usefulness in the Human Health Risk Assessment (U.S. EPA, 1991).

8.2.3 Hazard Identification

Following the first two data evaluation steps outlined above (data collection and data useability), the hazard identification is performed. The objective of the hazard identification is to select COCs and determine which are present at OU11 in concentrations high enough to be of concern relative to human health considerations. The criteria for performing the hazard identification may include but not be limited to (U.S. EPA, 1989b):

- Frequency of detection;
- Environmental media concentrations in excess of background concentrations;
- Toxicity, mobility, and persistence; and
- Historical chemical use at the RFP.

From the list of valid data suitable for use in the risk assessment, potential site-specific COCs are identified based on the following considerations:

- The concentration of the chemical exceeds human health and/or environmental standards (ARARS);

- The chemical is detected at a frequency greater than five percent of the time in an individual media (e.g., surface soil, subsurface soil, alluvial groundwater, etc.);

- The concentration of the chemical exceeds the background concentrations;

- The chemical is a potential carcinogenic compound classified as: Group A - sufficient evidence of carcinogenicity in humans, Group B1 - limited evidence of carcinogenicity in humans, and Group B2 - sufficient evidence in animals with inadequate evidence in humans, Group C - possible human carcinogen;

- The occurrence of a non-carcinogenic compound in media at a concentration 0.1 times the derived media concentration (DMC). (The DMC equals the exposure dose divided by the reference dose); and

- The chemical's role as a nutrient.

Based on the existing WSF data, as discussed in Section 2.3, potential COC types include nitrates, heavy metals, VOCs, plutonium, and uranium in shallow soils. Potential COCs in groundwater include nitrates, heavy metals, VOCs, magnesium, sodium, plutonium, americium, and uranium. A final determination regarding the selection of COCs for the WSF will be contained within one of the four technical memoranda to be submitted in accordance with the IAG.

8.3 EXPOSURE ASSESSMENT

The objective of the exposure assessment is to determine how exposures to site contaminants can occur, and to estimate the extent of exposure if it occurs. The exposure assessment includes the following tasks (per U.S. EPA guidance, 1989b):

- Characterize the exposure setting relative to contaminant fate and transport and potentially exposed populations;
- Identify exposure pathways based on chemical source and release, exposure point, and exposure route; and
- Identify uncertainties associated with the exposure assessment that impact the risk characterization.

Exposure is defined as the contact of an organism with a contaminant or physical agent. The magnitude of exposure is determined by measuring or estimating the amount of a contaminant available at the exchange boundaries (i.e., lungs, intestines, and skin). Exposure occurs when contaminants migrate from the site to an exposure point, when a receptor directly contacts the contaminated media, or in the case of radionuclides, when a receptor receives external radiation exposure.

8.3.1 Conceptual Site Model

The site conceptual model for OU11, as discussed in Section 2.4 and outlined in Figures 2-9 and 2-10, will be used to evaluate primary and secondary contaminant sources and releases, and potential receptors and associated exposures. The model helps to characterize the exposure setting relative to contaminant fate and transport mechanisms through exposed receptors. The conceptual site model for OU11 will be revised as Phase I RFI/RI data is collected. Although not explicitly described by the OU11 conceptual site model, existing occupational exposure pathways and future use residential exposure pathways will be considered for evaluation in the risk characterization. Details regarding exposure pathway identification will be addressed in one of the four Baseline Risk Assessment technical memoranda. A completed exposure pathway consists of all five of the elements listed below:

1. Source of contaminant;
2. Mechanism of chemical release to the environment;
3. Environmental transport medium (e.g., air, groundwater) for the released constituent;
4. Point of potential contact of human or biota with the affected medium (the exposure point); and
5. Exposure route (e.g., inhalation of contaminated dust) at the exposure point.

If any of these five elements is missing from a potential pathway, exposure cannot occur and thus the pathway can be eliminated from the risk assessment process.

The conceptual model in Section 2.4 outlines all potential existing and future use exposure pathways. Part of the goal of the RFI/RI Work Plan is to determine if any of the pathways meet the definition of complete. In addition, pathways found to be irrelevant, insignificant, or improbable, will be eliminated from the process. Details regarding the existing and future use exposure pathways relevant to the West Spray Field will be included within one of the four technical memoranda to be submitted in accordance with the IAG.

8.3.2 Contaminant Fate and Transport

The conceptual site model helps identify potential contaminant fate and transport mechanisms. Mechanisms relevant to the WSF-OU11 include soil contaminants leaching to groundwater, soil entrainment and downwind deposition, or surface runoff that transports surface soil and sediment downslope. Contaminant-specific characteristics also affect fate and transport. Chemical behavior factors affecting the probability a contaminant will migrate include, but are not limited to:

- Solubility;
- Partition coefficient;
- Vapor pressure;
- Henry's Law constant; and
- Bioconcentration factor.

The evaluation of these factors will help determine if contaminants can migrate from their sources to potential receptors, not only those identified under current use scenarios but those identified under potential future exposure scenarios as well.

8.3.3 Exposure Pathways

By using the conceptual site model and information on contaminant fate and transport, exposure pathways can be identified. The Human Health Risk Assessment will consider only complete exposure pathways (or pathways that could be complete under potential future situations), those for which data support the presence of a source, release mechanism, transport mechanism, exposure route, and affected receptor. Potential current use and future use exposure pathways will be described in the technical memoranda developed in accordance with the IAG.

8.3.4 Potential Receptors

Exposure of potential future receptors to contaminated media within OU11 for various land use scenarios including residential, industrial, recreational and restricted access, and exposure of off-site receptors to potentially contaminated groundwater, surface water, and airborne soil particulates will be addressed within the IAG technical memoranda. Exposure scenarios will be developed by employing such information as contaminant sources (Section 2.3), local topography (Section 1.3), and meteorological data such as prevailing wind direction (Section 1.3). This information will allow development of both on-site scenarios and off-site scenarios such as potential inhalation of windblown soil contaminants.

8.3.5 Exposure Point Concentrations

By preparing the data set as described in Section 8.2, Data Collection and Data Evaluation, exposure point concentrations of COCs will be estimated based on analytical results of the sampling program outlined in Section 7.0 of this Work Plan, and available relevant existing data, outlined in Section 2.3. Some data will be collected at the point of exposure. The majority of the data will be collected at the source and will be used in conjunction with a transport model to estimate expected concentration at some exposure point. Because modeling may add uncertainty, the emphasis will be on collecting data at exposure points where possible.

Release and transport of contaminants in environmental media may be modeled using basic analytical models recommended by EPA or the best model available, as determined by a model performance evaluation. The models will be calibrated to improve performance using site-specific parameters, where possible.

Model outputs will be characterized by estimating variance through an uncertainty analysis to the extent required by the overall risk uncertainty analysis. Efforts will be made to reduce the variance of model output. Other major contributors to the overall risk assessment uncertainty include exposure factors used in the estimation of intake and the toxicity parameters (reference dose and cancer slope factors) used to evaluate the effect of an acquired dose.

Exposure point concentrations will be expressed as reasonable maximum exposure (RME) concentrations and average concentrations. RME point concentrations and average exposure point concentrations are used in conjunction with receptor activity patterns to estimate contaminant intake for each exposure route as appropriate. The RME is the highest exposure that is reasonably expected to occur at a site. The intent of the RME is to estimate a conservative exposure case that is well above the average case, but is still within the range of possible exposures. Details regarding the RME will be developed during the Human Health Risk Assessment and contained within the technical memoranda.

RME concentrations are represented by the 95th percent confidence limit on the average or the maximum-reported concentration, whichever is lower. Depending on the quantity of data and their appropriateness for grouping, data distribution will be used to determine the appropriateness using geometric or arithmetic means to estimate the RME concentrations.

8.3.6 Contaminant Intake Estimation

In general, chemical intakes will be estimated using available, region-specific exposure parameters. Nonradioactive contaminant exposure (or intake) is normalized for time and body weight and is expressed as milligrams of contaminant per kilogram of body weight per day (mg/kg/day). Six basic factors are used to estimate nonradioactive intake: exposure frequency, exposure duration, contact rate, chemical concentrations, body weight, and averaging time. These factors are based on the types of exposure (e.g., residential or occupational, ingestion, or inhalation). The generic equation for calculating chemical intakes for any exposure route is outlined below (per U.S. EPA Risk Assessment Guidance for Superfund), (1989b):

$$I = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT}$$

I = intake; the amount of chemical at the exchange boundary (mg/kg body weight - day)

C = chemical concentration; the average concentration contacted over the exposure period (e.g., mg/liter water)

CR = contact rate; the amount of contaminated medium contacted per unit time or event (e.g., liter/day)

EFD = exposure frequency and duration; describes how long and how often exposure occurs. Often calculated using two terms (EF and ED):

EF = exposure frequency (days/year)
ED = exposure duration (years)

BW = body weight; the average body weight over the exposure period (kg)

AT = averaging time; period over which exposure is averaged (days)

Radioactive contaminant exposure will be calculated as outlined in "Radiation Safety at Superfund Sites," (U.S. EPA, 1990b) through the calculation of an absorbed dose which is converted into a dose equivalent. Details regarding non-radioactive intake parameters and radiation exposure for the West Spray Field Baseline Risk Assessment will be outlined in the IAG specified technical memoranda.

EPA requires using 95th percentile rates, 90th or 95th percentile values for exposure duration, and average values for parameters such as body weight. For example, a residential land use scenario describes an adult, weighing 70 kilograms, who works at home and consumes two liters of water and breathes 20 cubic meters (m^3) of air per day. The individual stays at home 350 days per year and lives in the same residence for 30 years. Different parameters are used for children, adult workers, and recreational exposures based on information provided by EPA in the *Human Health Evaluation Manual Supplemental Guidance, "Standard Default Exposure Factors" Interim Final,* March 25, 1991 (EPA, 1989e). Also, the averaging time for carcinogens and non-carcinogens differ.

Other standard intake rates established by EPA that will be used, if appropriate, include the following:

- Soil ingestion rates for children ages 1 through 6;
- Soil ingestion rates for all others (workers and residents more than 6 years of age); and
- Inhalation rates based on activity levels.

Contaminant rates can also be estimated for dermal exposures. Of the three routes of exposure (ingestion, inhalation, and dermal), the greatest uncertainty is associated with dermal exposures. Part of this uncertainty results from the lack of chemical-specific permeability constants.

Human intake of COCs will be estimated using reasonable estimates of exposure parameters. EPA guidance, site-specific factors, and professional judgement will be applied in establishing exposure assumptions. Using reasonable values allows estimation of risks associated with the assumed exposure conditions without underestimating actual risk. The estimate of intake is the "intake factor," which may then be mathematically combined with the exposure point concentrations and the critical toxicity values to determine cancer risks and hazard indices.

Depending on the data collected and the refinement of the conceptual site model, nontraditional exposure routes that may be included in the Human Health Risk Assessment, include fish ingestion and exposures resulting from recreational uses of the reservoirs (contact with sediments, ingestion, and dermal contact with surface water) and the nearby open spaces (hiking, bicycling).

Other nontraditional exposure routes may be identified by using land use data for the OU11 area. These include exposure scenarios related to agricultural land uses and other recreational land uses within the OU11 area.

8.3.7 Uncertainty in the Exposure Assessment

The ability to construct exposure scenarios for a site depends on the amounts and kinds of environmental data collected for that purpose. Some uncertainty is inherent in environmental data collection. The numbers and kinds of uncertainties included in the exposure assessment directly impact the risk characterization. In addition, professional judgements impact the identification and description of physical site attributes that affect exposure and activity patterns. One of the major areas of uncertainty in the exposure assessment is the prediction of human activities that lead to contact with environmental media and exposures to site-related contaminants. The uncertainty analysis of the Human Health Risk Assessment is used to identify and describe how such factors as environmental sampling and analysis, fate and transport modeling, and exposure parameter estimation affect uncertainty relative to assessing risk.

The uncertainty analysis will identify and evaluate non-site-specific and site-specific factors that may produce uncertainty in the risk assessment, such as assumptions inherent to development of toxicological endpoints (potency factors, reference doses) and assumptions considered in the exposure assessment (model input variability, population dynamics). Statistical sampling techniques (such as Monte-Carlo) may be employed for contaminants for which quantitative evaluation is not possible. The goal of this task will be to quantify, to the extent practicable, the magnitude and extent of uncertainty propagated through the risk assessment process. The uncertainty analysis will present the spectrum of potential risks under specified scenarios such that the risk management decision maker can obtain an understanding of the level of confidence associated with all estimates of potential human health risk.

8.4 TOXICITY ASSESSMENT

The objective of the toxicity assessment is to describe the contaminants considered in the Human Health Risk Assessment relative to their potential to cause harm. The toxicity assessment has two general steps. The first determines what adverse health impacts, if any, could result from exposure to a particular contaminant. These are typically classified as carcinogenic and non-carcinogenic health effects. The second step, dose-response evaluation, quantitatively examines the relationship between the level of exposure and the incidence of adverse health effects.

Toxicity depends on the dose or concentration of the substance (dose-response relationship). Toxicity values are a quantitative expression of the dose-response relationship for a contaminant and take the form of reference doses (RfD) and cancer slope factors, both of which are specific to exposure via different routes.

Two sources of toxicity values are currently available for chemicals and radionuclides. The primary source is the EPA's Integrated Risk Information System (IRIS) database. IRIS contains up-to-date health risk and regulatory information. IRIS contains only those RfDs and slope factors that have been verified by the U.S. EPA work groups and is considered by U.S. EPA to be the preferred source of toxicity information for chemicals.

In addition to IRIS, the most recently available Health Effects Assessment Summary Tables (HEAST), issued by the U.S. EPA's Office of Research and Development, will be consulted to identify interim RfDs and slope factors for radionuclides.

To judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems), the projected concentrations of COCs at exposure points will be compared with ARARs, as stated in Section 3.0 of this Work Plan. Receptors may be exposed to contaminants in more than one medium so that their total doses might exceed risk reference doses (RfDs) and/or might result in an excess cancer risk greater than an acceptable target risk, as defined by EPA (e.g., 10^{-6} to 10^{-4}). As discussed in Section 3.0, the following criteria will be examined:

- Drinking-water health advisories;
- Ambient water quality criteria for protection of human health;
- Center for Disease Control and Agency for Toxic Substances and Disease Registry soil advisories;
- National Ambient Air Quality Standards;
- State (CDH/CWQCC) Surface Water Quality Standards;
- Federal Surface Water Standards; and
- State (CDH/CWQCC) Groundwater Quality Standards.

In addition to identifying appropriate toxicity values, this section of the Human Health Risk Assessment will provide brief toxicity profiles based on recent, published literature for each contaminant evaluated in the Human Health Risk Assessment. These profiles will describe the acute, chronic, and carcinogenic health effects associated with site-related contaminants identified in OU11. Acute and chronic exposure to site-related radionuclides will be discussed, but most of the information presented will deal with the carcinogenic hazard posed by the site-specific radionuclides. Details regarding the contaminant toxicity assessment will be outlined within the Baseline Risk Assessment technical memoranda per the IAG.

8.5 RISK CHARACTERIZATION

This section of the Human Health Risk Assessment presents the evaluation of potential risks to public health associated with exposure to contaminants at the OU11 site. Potential carcinogenic and non-carcinogenic risks associated with complete exposure pathways will be estimated. Risk characterization involves integrating exposure assumptions, estimates of contaminant intakes and toxicity information to quantitatively and qualitatively estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA guidance (U.S. EPA, 1989b).

Non-cancer risk will be assessed by comparing the estimated daily intake of a contaminant to its RfD. This comparison measures the potential for non-carcinogenic health effects given the chemical intake factors used to estimate exposure. To assess the potential for non-cancer effects posed by multiple chemicals, EPA's hazard index approach will be used. This method assumes dose additivity. Hazard quotients (individual chemical intake divided by the chemical RfD) are summed to provide a hazard index, and if the index exceeds one, a potential for health risk is suggested. If a hazard index exceeds one, where possible, chemicals may be segregated by similar effect or target organ to determine the potential health risks. Separate hazard indices may be derived for each effect if sufficient information or target organ specificity is available.

In addition to evaluating multiple dose additivity, synergistic affects will be evaluated, if determined appropriate.

The potential for carcinogenic effects will be estimated by calculating excess lifetime cancer risks from the lifetime average exposure and cancer slope factor. These will be upper-bound estimates because methods used to estimate slope factors are regarded as upper bounds on potential cancer risks rather than accurate representations of true cancer risk.

Both non-cancer and cancer risks will be estimated by using RME and average contaminant intake values combined with exposure assumptions. This allows risk ranges to be considered rather than a single value and more closely considers the uncertainty associated with the estimates. In addition, risks may be added across exposure routes to assess the potential for additive affects. All risk calculation results will be presented in tabular form which will include individual risks for the COCs via the relevant exposure routes. In addition, total risks for the relevant exposure routes and total risk posed by the WSF will be presented.

Not all contaminants identified at OU11 will have toxicity values, thereby limiting the ability to develop quantitative estimates of risk. Where adequate toxicity values cannot be identified, potential risks associated with exposure to those constituents will be dealt with qualitatively.

8.6 UNCERTAINTIES, LIMITATION, AND ASSUMPTIONS

The numbers and kinds of uncertainties identified in the Human Health Risk Assessment directly impact the interpretation of estimated risks developed in this section. Quantitative risk estimates derived in risk assessments are conditional estimates that include numerous assumptions about exposures and toxicity. Uncertainty is introduced from a variety of sources, including, but not limited, to:

- Sampling and analysis,
- Exposure estimation, and
- Toxicological data.

As part of the Human Health Assessment, uncertainty will be described qualitatively in terms of under- or over-estimation of risk, or both. If necessary, uncertainty may be described quantitatively using sensitivity analyses or other numerical models if a rigorous analysis is required.

TABLE 8-1

EPA GUIDANCE DOCUMENTS WHICH MAY BE USED IN THE RISK ASSESSMENT TASK

EPA's Integrated Risk Information System (IRIS) — Office of Research and Development (continuously updated). Agency's primary source of chemical-specific toxicity and risk assessment information. Includes narrative discussion of toxicity database quality and explains derivation of Reference Doses, cancer potency factors, and other key dose response parameters. IRIS presents information that updates data originally presented in Exhibits A-4 and A-6 of the SPHEM (see below). Further information: IRIS Users Support, 513-569-7254.

Health Effects Assessment Summary Tables (HEAST) — Office of Research and Development/Office of Emergency and Remedial Response (updated quarterly). Because the IRIS chemical universe (while growing) is currently incomplete, the HEAST has been produced to serve as a "pointer" system to identify current literature and toxicity information on important non-IRIS chemicals. While HEAST data, in some cases, may not be "Agency-verified," the information is considered valuable for Superfund risk assessment purposes. Available from Superfund docket, 202-382-3046 (U.S. EPA, updated quarterly).

Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final — Office of Emergency and Remedial Response. This volume provides updated risk assessment procedures and policies, specific equations and variable values for estimating exposure, and a hierarchy of toxicity data sources. There is an expanded chapter on risk characterization to help summarize information for the decision makers and detailed descriptions of uncertainties in risk assessment (U.S. EPA, 1989b).

OSWER Directive on Soil Ingestion Rates — Office of Solid Waste and Emergency Response (January 1989), OSWER Directive No. 9850.4. Recommends soil ingestion rates for use in risk assessment when site-specific information is not available. Available from Darlene Williams, 202-475-9810 (U.S. EPA, 1989b).

Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference — Office of Solid Waste and Emergency Response EPA 600-3/89/013. This report is a field and laboratory reference document that provides guidance on designing, implementing, and interpreting ecological assessments of hazardous waste sites. It includes sections on ecological endpoints, field sampling design, quality assurance, aquatic and terrestrial toxicity and field survey methods, recommended biomarkers, and data analysis (U.S. EPA, 1989d).

Risk Assessment Guidance for Superfund — Environmental Evaluation Manual, Interim Final (RAGS-EEM) — Office of Emergency and Remedial Response (March 1989), EPA/540/1-89/001A. Provides program guidance to help remedial project managers and on-scene coordinators manage ecological assessment at Superfund sites.

TABLE 8-1 (continued)

EPA GUIDANCE DOCUMENTS WHICH MAY BE USED IN THE RISK ASSESSMENT TASK

Exposure Factors Handbook — Office of Research and Development (March 1989), EPA/600/8-89/043. Provides statistical data on the various factors used in assessing exposure; recommends specific default values to be used when site-specific data are not available for certain exposure scenarios. Further information: Exposure Methods Branch, 202-382-5988 (U.S. EPA, 1989e).

Superfund Public Health Evaluation Manual (SPHEM) — Office of Emergency and Remedial Response (November 1986a), EPA/540/1-86/061. Describes sources of information useful in conducting risk assessments. Currently under revision.

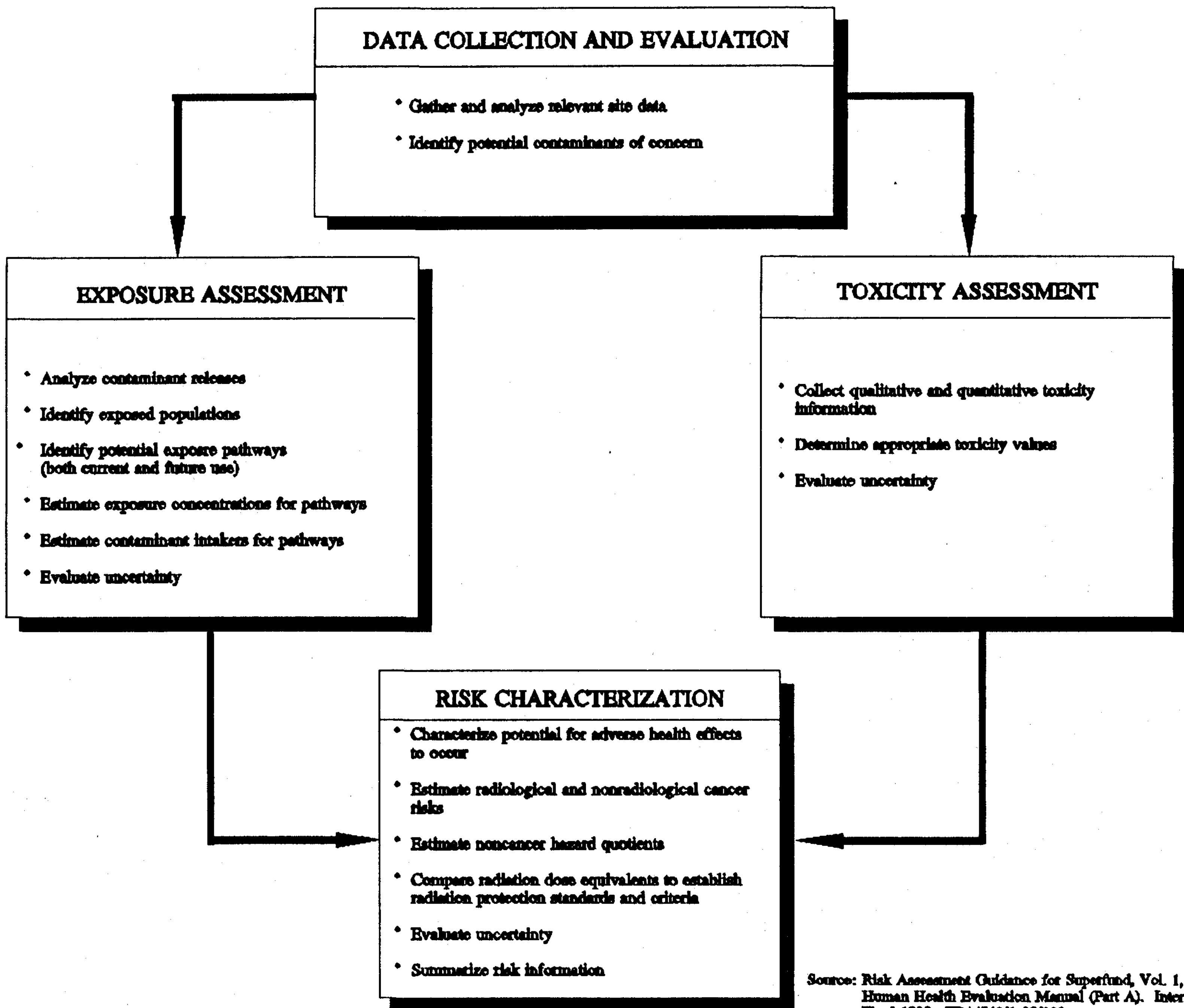
Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA — Office of Emergency and Remedial Response EPA/540/8-89/004. This guidance document is a revision of the U.S. EPA's 1985 guidance. It describes general procedures for conducting an RI/FS (U.S. EPA, 1988a).

Superfund Exposure Assessment Manual (SEAM) — Office of Emergency and Remedial Response (April 1988), EPA/540/1-88/001. Provides a framework for the assessment of exposure to contaminants at or migrating from hazardous waste sites. Discusses modeling and monitoring (U.S. EPA, 1988d).

CERCLA Compliance with Other Laws Manual — Office of Emergency and Remedial Response. The guidance is intended to assist in the selection of on-site remedial actions that meet the applicable or relevant and appropriate requirements (ARARs) of the Resource Conservation and Recovery Act (RCRA), Clean Water Act (CWA), Safe Drinking Water Act (SDWA), Clean Air Act (CAA), and other federal and state environmental laws as required by CERCLA, Section 121 (U.S. EPA, 1988b).

Guidance for Data Useability in Risk Assessment — Office of Solid Waste and Emergency Response, (Interim Final 1990). EPA/540/G-90/008. This guidance contains minimum data quality requirements designed to increase the useability of environmental analytical data in the cleanup of hazardous waste sites under CERCLA and SARA.

FIGURE 8-1
HUMAN HEALTH RISK ASSESSMENT



Source: Risk Assessment Guidance for Superfund, Vol. 1, Human Health Evaluation Manual (Part A). Interim Final 1989. EPA/540/1-89/002

9.0 ENVIRONMENTAL EVALUATION

9.1 INTRODUCTION

The purpose of this Environmental Evaluation (EE) Work Plan is to provide a framework for addressing risks to the environment from contaminants within Operable Unit 11 (OU11), the West Spray Field (WSF). This investigation of contamination at OU11 primarily falls under the purview of RCRA, but according to the Interagency Agreement for Rocky Flats, CERCLA and RCRA programs will be integrated. Therefore, guidance for preparation of this work plan was taken from U.S. Environmental Protection Agency (EPA) technical guidance documents for conducting ecological assessments, including "Risk Assessment Guidance for Superfund, Vol. II, Environmental Evaluation Manual" (U.S. EPA 1989a) and "Ecological Assessments of Hazardous Waste Sites: A Field and Laboratory Reference Document" (U.S. EPA 1989b). This work plan was also designed to comply with requirements associated with the Natural Resource Damage Assessment process (43 CFR Subtitle A).

The WSF was designated Operable Unit 3 (OU3) until January 1991, when its designation was changed to OU11. Many of the documents reviewed in preparation of this work plan were published prior to the OU11 designation. For consistency, WSF is referred to as OU11 throughout the balance of this work plan. OU11 comprises Individual Hazardous Substance Site (IHSS) No. 168 and is located just west of the westernmost office trailer complex on plant site (Figure 2-1).

The goal of the EE is to determine the nature and extent of present and potential impacts of OU11 contaminants on biota. Determination of the effects on biota will be coordinated with the Human Health Risk Assessment for OU11. This EE will also be coordinated with the OU5 (Woman Creek Priority Drainage) RFI/RI work plan, the OU6 (Walnut Creek Priority Drainage)

RFI/RI work plan, the site wide surface water and sediments monitoring program, and the RCRA groundwater monitoring program. Criteria necessary for performing the EE will be developed in conjunction with Human Health Risk Assessments and EEs for all Rocky Flats Plant (RFP) operable units. Information from the EEs will support determination of the need, form, feasibility, and extent of remediation necessary for OU11 in accordance with RCRA, other relevant statutory requirements, and sound management practices.

Documents reviewed during preparation of this work plan include the Final Environmental Impact Statement (EIS), RFP (U.S. DOE 1980); Wetlands Assessment (EG&G 1990a); West Spray Field Draft Phase I RFI/RI Work Plan (EG&G 1990b); West Spray Field Closure Plan (Rockwell International 1988); Draft 1989 Surface Water and Sediment Report; The Background Geochemical Characterization Report (EG&G 1991a), Phase I RFI/RI Work Plan, Walnut Creek Priority Drainage OU6 (EG&G 1991b); and Phase I RFI/RI Work Plan, Woman Creek Priority Drainage OU5 (EG&G 1991c). Literature review will continue as new data become available throughout the EE.

9.2 SITE CHARACTERIZATION

9.2.1 OU11 Contamination

Preliminary assessment of possible contamination at OU11 was made on the basis of wastewater characterization data for Solar Evaporation Pond (Pond) 207-B North and Pond 207-B Center for the periods of spraying, soil sampling data at OU11 (then OU3) in 1986 and 1988, and groundwater monitoring data. Information sources include the Draft Phase I RFI/RI Work Plan for West Spray Field (EG&G 1990b), the 1990 Annual RCRA Groundwater Monitoring Report (EG&G 1991c), and the Background Geochemical Characterization Report for 1989 (EG&G 1990c). This section summarizes the information and data presented in Section 2.0 that is pertinent to the ecological risk assessment. The emphasis of the Phase I RFI/RI sampling program will be on soil contamination at OU11. Surface water and groundwater data are presented because of the potential impact to biota downgradient from OU11.

9.2.1.1 Wastewater Characterization

The WSF received spray application of excess water from Pond 207-B North and Pond 207-B Center from April 1982 to October 1985 (Rockwell 1986b, 1988; Weston 1986a,b) and reviewed here. Water in Pond 207-B North originated from an interceptor system installed to collect groundwater seepage from the hillside north of the Solar Evaporation Ponds. Analysis of wastewater in the ponds is important because any nonvolatile chemical in the spray water would be concentrated as during evapotranspiration from spray field soils and vegetation. By this mechanism chemicals found at relatively low concentrations in wastewater could become concentrated in soils.

A summary of wastewater characterization of Pond 207-B North and Pond 207-B Center is presented in Appendix E of the Phase I RFI/RI Work Plan. Pond 207-B Center received treated sanitary effluent from the wastewater treatment plant. Review of surface water data from 1984-1988 indicates that, during spray application, water in the ponds may have contained elevated levels of nitrate (as nitrogen), uranium-233+234 uranium-238, tritium, gross alpha, and gross beta radiation. Lead, mercury, and selenium were also detected at low concentrations in pond water. Volatile organic compounds (VOCs) were detected in the water samples from the 207-B ponds and the groundwater intercept system. The presence of methylene chloride in water samples collected from the 207-B ponds may have been the result of laboratory contamination because it was also detected in the "blanks." Chloroform, carbon tetrachloride, and trichloroethylene were also identified in samples collected from the groundwater intercept system. Although both sediment samples collected from the groundwater intercept system in

1986 contained methylene chloride, it is possible that this was also a result of laboratory contamination. No pesticides, polychlorinated biphenyls (PCBs), or other semi-volatile compounds were found in the water or sediment samples.

A detailed history and a description of the spray equipment and configuration are found in Section 2.0 of the Phase I RFI/RI work plan. The areas of direct spray application total approximately 14 acres and are located in three main areas (Figure 2-1). Area 1, the westernmost and largest of the areas, received water from both 207-B North and 207-B Center via three fixed irrigation lines. Area 1 totals approximately 36 acres, 8.4 acres of which received direct spray application. Area 2 is a linear area of approximately 2.5 acres (1360 feet x 80 feet) located just east of the road that roughly bisects OU11. All of Area 2 received direct spray application primarily from Pond 207-B Center. Area 3, located east of Area 2, comprises many small circular spray areas with the source area totaling approximately 3.2 acres. Area 3 received sanitary wastewater from Pond 207-B Center. On the basis of total volumes applied during operation, the estimated total application was approximately 40 inches per unit area from Pond 207-B North applied to Area 1, and approximately 150 inches from Pond 207-B Center applied to Areas 1, 2, and 3.

9.2.1.2 Soils

Few data exist on contaminants present in surficial materials at OU11. Soils were analyzed for contamination during two studies, in 1986 and 1988, which are described in detail in Section 2.0 of the Phase I RFI/RI work plan. The 1986 study included samples taken from two grids located in Area 1 (Figure 2-1). Collection included surficial soil scrapes and samples from 0- to 6-inch and 6- to 12-inch depth intervals (see Section 2.0 for details). The 1986 sampling plot in Area 1 was not in an area of direct spray application, but results indicate that it may have been affected by windblown spray. The analytes for the 1986 study are presented in Table 2-4, and the results are presented in Tables 2-5, 2-6, and 2-7 of the RFI/RI work plan. In the 1988 study, samples were taken from 12 test pits excavated within the OU11 boundary (Figure 2-1). The analytes for the 1988 study are presented in Table 2-8, and the results are presented in Tables 2-9, 2-10, 2-11, and 2-12 of the RFI/RI work plan.

The metals arsenic, lead, mercury, and zinc were found at levels significantly above background in the soils studies (Table 9-1). These metals are of particular concern since they tend to bioaccumulate. Data for radionuclide concentrations in OU11 soils are presented in Table 9-1 (see also Table 2-6 of the RFI/RI work plan). Radionuclide concentration measurements with error terms larger than their respective measured values are generally not considered statistically different from the environmental background (Rockwell International 1988b, Vol. II, p. 4-27). The values recorded during the 1986 and 1988 soils studies are compared to the site wide background in OU11 soils. The error terms associated with americium-241 and plutonium-239 measurements exceeded the measured values and are therefore not considered above background. The 1986 soil samples were not analyzed for nitrate. However, in the 1988 study, nitrate (as N) concentration was elevated in samples from each of the sprayed areas (Table 9-1; see also Table 2-11 of the RFI/RI work plan). Samples from Area 1 exhibited concentrations 5 to 20 times the background value (Table 2-11, RFI/RI work plan).

The RFP annual soil monitoring program included several sites north and west of OU11, which could be considered upgradient of the site and therefore unimpacted (EG&G 1990). Samples were collected from the top 5 cm of soil and analyzed for plutonium. Also included were two sites within OU11 (1-270 and 1-252). The plutonium concentration in the OU11 samples (0.07 ± 0.01 pCi/g at 1-270 and 0.12 ± 0.04 pCi/g at 1-252) was within the range of the concentration in samples from upgradient areas (0.08 ± 0.040 pCi/g; n=12; range 0.03-0.15 pCi/g).

The maximum concentration of metals and radionuclides detected at OU11 are compared to the RFP site wide background and relevant RCRA criteria in Table 9-1. However, the background levels in Table 9-1 are from the Background Geochemical Characterization Report (EG&G 1990c) and are based on data from alluvial borehole samples. There are currently no official "background" concentrations specifically for metals or radionuclides in surficial or A-horizon materials. In addition, neither the background data nor the OU11 soil data includes the form in which the chemicals analyzed were found. This may be important because less soluble compounds will be more resistant to leaching and therefore more likely to remain in the upper soil layers. More soluble compounds are more likely to leach into deeper materials. It may be reasonable to expect that concentrations of certain compounds are naturally higher in surficial materials in Rocky Flats soils. On the other hand, it is also important to note that any of the chemicals contained in spray water would be concentrated by evaporation of the water vehicle. Metals and other constituents may complex with carbonates or other chemicals already present in the soil, and form largely insoluble compounds that would tend to remain in surface layers. Such a mechanism could result in concentration of the metals or radionuclides in the surficial soil.

Because the upper soil layers are the most critical to vegetation and animal life, it may be important to establish the "background" concentrations for the upper 10 cm, or for the A-horizon in the WSF. It will also be important to determine the form in which the contaminants are found in order to assess their potential toxicity to ecological receptors. Aqueous solubility also contributes to the bioavailability and ultimately the toxicity of metals and radionuclides. More soluble metals may be more likely to enter a plant or animal through ingestion or bulk water absorption and, once internalized, more likely to cross tissues or to be taken up by cells.

Methylene chloride, trichlorethene, carbon disulfide, 1,1,1-trichloromethane, and 1,1,2-trichlorethane were detected in soils at OU11. Presence of the same compounds in sampling and laboratory blanks indicated laboratory contamination (Table 2-7, RFI/RI work plan). Therefore, it is not possible to fully evaluate whether the detected concentrations of these compounds are actually contaminants in soil at OU11. Inspection of the data in Tables 2-7 and 2-12 of the RFI/RI work plan indicates that VOCs are generally near or below detection limits.

9.2.1.3 Groundwater

Compounds deposited on soils by spray application may leach into shallow (alluvial) groundwater at OU11. Contaminants transported away from the source area in groundwater may in turn threaten surface waters and deeper aquifers. Groundwater in OU11 monitoring wells contained elevated (above background) levels of lead, cadmium, aluminum, nitrates, cyanide, uranium-233+234, acetone, and toluene. This suggests that these compounds may have been leached from sprayed soils (Table 9-2).

9.2.1.4 Surface Water

Although there are no natural permanent surface water features in OU11, contamination of surface water downgradient could result from the migration of soil or groundwater contaminants. Data from four surface water monitoring stations (SW006, SW093, SW107, and SW041) are presented in Table 9-3. SW006 lies to the north of OU11 in the extreme upper Walnut Creek drainage; SW093 is in the Walnut Creek drainage, downstream of OU11 and directly north of the Solar Evaporation Ponds. SW107 and SW041 lie directly south of OU11 in the Woman Creek drainage. Aluminum, arsenic, and lead were elevated above background in samples from all four stations. Cyanide was elevated at SW006 and SW107. Selenium was elevated at just one station, SW093. Strontium-89, strontium-90, uranium-233+234 and uranium-238 were also elevated in surface water at one or more stations. Contamination of surface water may have originated from OU11, but this cannot be determined without further investigation because other sources, such as IHSSs within OU5 and OU4, could have contributed the same contaminants.

9.2.2 Ecological Characterization

9.2.2.1 General

Terrestrial and aquatic species in the RFP area have been described by several researchers (Quick 1964, Weber et al. 1974, Winsor 1975, Clark 1977, Clark et al. 1980, U.S. DOE 1980, and CDOW 1981, 1982a and 1982b). In addition, terrestrial and aquatic radioecology studies conducted by Colorado State University and DOE (Johnson et al. 1974, Little 1976, Hiatt 1977, Paine 1980, Rockwell International 1986a), along with annual monitoring programs at the RFP, provide information on the movement of contaminants through ecological pathways. Ongoing studies include the Baseline Vegetation and Wildlife site wide study and the EEs for OUs 1, 2, and 5. These studies are currently scheduled for completion in FY92.

The RFP is located at an elevation of approximately 6,000 feet, just below the elevation at which plains grasslands grade abruptly into lower montane (foothills) forests (Marr 1964). The present vegetation of the RFP and adjacent areas is dominated by mixed-grass prairie but includes various mosaics of short-grass steppe and mid- to tall-grass prairie. Tall-grass prairie, endemic to the foothills and mesas, is absent in many areas around the RFP as a result of grazing and development. Some areas at the RFP do show the influence of previous grazing, but much of the site is dominated by big bluestem (*Andropogon gerardii*) and other species indicative of low-grazing pressure. Most of the broad divides and hillsides are dominated by a mixture of native grasses, forbs (broadleaf species), and subshrubs. Prevalent species include prairie junegrass (*Koeleria macrantha*), western wheatgrass (*Agropyron smithii*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), green needlegrass (*Stipa viridula*), needle-and-thread (*Stipa comata*), big bluestem, little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), blue grama (*Bouteloua gracilis*), side-oats grama (*Bouteloua curtipendula*), and red three-awn (*Aristida longiseta*). Non-native weedy forbs and annual grasses are locally prominent in disturbed or previously grazed sites. Introduced pasture grasses such as smooth brome (*Bromopsis inermis*), intermediate wheatgrass (*Agropyron intermedium*) and crested or desert wheatgrass (*Agropyron desertorum*) are present on sites where an attempt has been made to rehabilitate degraded range. Yucca (*Yucca glauca*), cacti, and several *Artemisia* species are conspicuous on xeric hilltop sites with shallow, rocky soils. Individuals or small clumps of ponderosa pine occur on some rock outcrops.

The valley floors and seeps on adjacent slopes support various wetland types, ranging from sedges, rushes (*Juncus sp.*), or cattails (*Typha sp.*) to stands of mature cottonwoods (*Populus sp.*), willows (*Salix sp.*), and leadplant (*Amorpha sp.*). Tall and short shrub stands throughout the site contain scattered clumps of wild plum (*Prunus americana*), chokecherry (*Prunus virginiana*), hawthorn (*Craetaegus sp.*), snowberry (*Symphoricarpos sp.*), and golden currant (*Ribes aureum*). Rocky sideslopes of the deeper ravines contain skunkbrush (*Rhus trilobata*) and ninebark (*Physocarpus monogynus*), two shrub species more characteristic of the lower foothills.

As in most of the Front Range Urban Corridor, wildlife at the RFP has been greatly influenced by the increase in human use and disturbance over the past 100 years. Most notable have been reductions in the number and diversity of ungulates (hoofed animals) and predators. However, the relative isolation and habitat diversity of the RFP have resulted in a fairly rich animal community.

During a mark-recapture program, Winsor et al. (1975) caught eight species of small mammals: the deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), meadow vole (*Microtus pennsylvanicus*), thirteen-lined ground squirrel (*Spermophilus* *tridecemlineatus*), northern pocket gopher (*Thomomys talpoides*), hispid pocket mouse (*Perognathus hispidus*), silky pocket mouse (*Perognathus flavus*), and house mouse (*Mus musculus*). Additional species collected during EE studies in 1991 included the meadow jumping mouse (*Zapus hudsonius*), prairie vole (*Microtus ochragaster*), and Mexican woodrat (*Neotoma mexicana*). These studies also revealed that both the western and plains harvest mouse (*Reithrodontomys montanus*) are present. White-tailed jackrabbits (*Lepus townsendii*) and cottontails (*Sylvilagus floridanus* and *S. audubonii*) also occur at the RFP. The most abundant large mammal is the mule deer (*Odocoileus hemionus*), of which an estimated 100-125 appear to be permanent residents (DOE 1980). Carnivores present include coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), raccoons (*Procyon lotor*), badgers (*Taxidea taxa*), long-tailed weasels (*Mustela frenata*), and striped skunks (*Mephitis mephitis*).

Common grassland birds at the RFP include western meadowlarks (*Sturnella neglecta*), horned larks (*Eremophila alpestris*), vesper sparrows (*Pooecetes gramineus*), lark sparrows (*Chondestes grammacus*), and grasshopper sparrows (*Ammodramus savannarum*). Wetlands support song sparrows (*Melospiza melodia*), common yellowthroats (*Geothlypis trichas*), and red-winged blackbirds (*Agelaius phoeniceus*). Northern flickers (*Colaptes auratus*), eastern and western kingbirds (*Tyrannus tyrannus* and *T. verticalis*), black-billed magpies (*Pica pica*), northern orioles (*Icterus galbula*), yellow warblers (*Dendroica petechia*), warbling vireos (*Vireo gilvus*), American robins (*Turdus migratorius*), indigo buntings (*Passerina cyanea*), blue grosbeaks (*Guiraca caerulea*), and lesser and American goldfinches (*Carduelis psaltria* and *C. tristis*), among other species, nest in cottonwood/willow stands. Wooded draws attract foothills species, including MacGillivray's warblers (*Opornis tolmiei*), yellow-breasted chats (*Icteria virens*), black-headed grosbeaks (*Pheucticus melanocephalus*), green-tailed and rufous-sided towhees (*Pipilo chlorurus* and *P. erythrophthalmus*), and lazuli buntings (*Passerina amoena*). Common birds of prey in the area include American kestrels (*Falco sparverius*), northern harriers (*Circus *cyaneus*), red-tailed hawks (*Buteo jamaicensis*), Swainson's hawks (*Buteo swainsoni*), and great horned owls (*Bubo virginianus*).

The most abundant reptiles are the bullsnake (*Pituophis melanoleucus*), yellow-bellied racer (*Coluber constrictor*), western terrestrial gartersnake (*Thamnophis elegans*), and prairie rattlesnake (*Crotalus viridis*).

Four streams flow within the RFP boundary: Rock Creek, North Walnut Creek, South Walnut Creek, and Woman Creek. All of these streams are ephemeral to intermittent, with peak flows during spring and early summer. The two forks of Walnut Creek also contain a series of small impoundments formed by earthen dams. The surface waters support a variety of aquatic macroinvertebrates, including snails, crayfish, as well as larvae or adults of several orders of Insecta (DOE 1980). Some of the ponds are inhabited by fathead minnows (*Pimephales promelas*), green sunfish (*Lepomis cyanellus*), and largemouth bass (*Micropterus salmoides*). The ponds also attract water birds such as mallards (*Anas platyrhynchos*), gadwall (*Anas strepera*), green-winged and blue-winged teal (*Anas crecca* and *A. discors*), spotted sandpipers (*Actitis macularia*), black-crowned night herons (*Nycticorax nycticorax*), and great blue herons (*Ardea herodias*). Killdeer (*Charadrius vociferus*) are common near pond margins, and muskrats (*Ondatra zibethicus*) occur in some areas. In addition, the ponds and creeks provide feeding habitat and water sources for various terrestrial species and breeding habitat for amphibians. Leopard frogs (*Rana pipiens*), Woodhouse's toads (*Bufo woodhousei*), and northern chorus frogs (*Pseudacris triseriata*) have all been observed at the RFP.

9.2.2.2 West Spray Field

The habitat at and around the WSF is predominately mesic mixed grassland with riparian shrubland along intermittent stream channels (Figures 9-1, 9-2, 9-3, and 9-4; also see Clark et al. [1977] and SOP 5.11 for identification of habitats at the RFP). As part of the preliminary site survey conducted in July 1991, cover and richness were determined for five transects in Spray Areas 2 and 3. Mean total cover was 92 percent, with an average richness of 22 species per transect. The area is dominated by Canada bluegrass and mountain muhly (*Muhlenbergia montana*) with inclusions of big bluestem, little bluestem, prairie junegrass, and blue grama. Smooth brome, cheatgrass (*Bromus tectorum*), and various weedy forbs are found in several small disturbed areas. Forbs in the area include Louisiana sage (*Artemisia ludoviciana*), annual sunflower (*Helianthus annuus*), slimflower scurfpea (*Psoralea tenuiflora*), moth mullein (*Verbascum blattaria*), tumble mustard (*Sisymbrium altissimum*), and purple prairie-clover (*Petalostemum purpurea*).

Five transects surveyed in the riparian shrubland areas just to the north of Spray Area 1 averaged 97 percent total plant cover with a mean richness of 23 species per transect. Canada bluegrass was also the dominant grass in this area, with Kentucky bluegrass and little bluestem as other important species. Common sage (*Artemisia campestris*), wild tarragon (*Artemisia dracunculus*), and cottonwoods saplings were also abundant. A reach of the Walnut Creek drainage directly north of Spray Area 2 is lined by mature cottonwoods.

No natural permanent aquatic habitats occur within OU11, but a raw water storage pond is located just south of Area 2. The headwaters of Walnut Creek lie just to the north of OU11, but the stream is intermittent at this point. The nearest permanent reaches of Walnut Creek lie 200 to 300 meters (m) to the east. Upper reaches of Woman Creek lie 300-400 m south of OU11.

Overall, the areas of previous spray application show no signs of impact to the vegetation community (Figures 9-2, 9-3, and 9-4). However, narrow (0.5 m) strips of barren ground are found where spray lines had been located. A shallow ditch, 0.5 to 1 m deep, is located on the eastern and northern edges of Spray Area 1 (Figures 2-1, 2-2, and 9-1). Much of the ditch is overgrown with native grasses but non-native weedy species line the ditch corridor.

9.2.2.3 Protected Species and Habitats

Endangered species potentially of interest in the RFP area are the black-footed ferret (*Mustela nigripes*), peregrine falcon (*Falco peregrinus*), and bald eagle (*Haliaeetus leucocephalus*) (EG&G 1991d). Black-footed ferrets are not known to occur in the vicinity of the RFP. Critical habitat for the black-footed ferrets consists primarily of colonies of its major food item, the prairie dog (*Cynomys lucovicianus*). Prairie dog colonies do not exist in the area of the WSF. Bald eagles occur occasionally in the RFP area, primarily as irregular visitors during the winter or migration seasons. No roost areas or nest sites exist at the' RFP. Peregrine falcons may occur as migrants, and a pair has reportedly nested approximately 10 km to the northwest in 1991. It is possible that the hunting territory of the nesting peregrines could include the RFP, although suitable habitat occurs closer to the nest area.

Other wildlife species of higher federal interest that are potentially present at the RFP include the white-faced ibis (*Plegadis chihi*), mountain plover (*Charadrius montanus*), long-billed curlew (*Numenius americanus*), and swift fox (*Vulpes velox*) (EG&G 1991d). To-date, these species have not been documented to occur at the RFP. Specimens of Preble's meadow jumping mouse (*Zapus hudsonius*) were captured in the Woman Creek drainage and in the Rocky Creek Drainage during early summer. However, subsequent efforts to confirm this observation yielded no captures. An additional species, the ferruginous hawk (*Buteo regalis*), has been observed at the RFP and is likely to visit the site irregularly as a migrant or winter vagrant. Ferruginous hawks may also breed in the RFP vicinity; if so, their hunting territory could include the RFP. Potential nesting sites include scattered trees and rocky ridgetops.

Four plant species of special concern that are potentially present include one species proposed for listing as a threatened species (Diluvium lady's tresses [*Spiranthes romanzoffiana*, Orchidaceae]), one species of high federal interest (Colorado butterfly plant [*Gaura neomexicana coloradensis*, Thymelaeaceae]), and two species of concern in Colorado (forktip three-awn [*Aristida basiramea*, Poaceae] and toothcup [*Rotala ramosior*, Lythraceae]).

The forktip three-awn was reported along Woman Creek in 1973 (EG&G 1991d) and during investigations conducted during the OU1 and OU2 EEs 1991 (F. Harrington personal communication).

Diluvium lady's tresses is an orchid that occurs in and near wetlands in Colorado, Nevada, and Utah, but is considered extremely rare in Colorado's front range. Specimens of have been reported near Clear Creek to the south of the RFP and near South Boulder Creek to the north of RFP (EG&G 1991d). The Colorado butterfly plant has not been reported near the RFP, but wetlands along major creeks represent suitable habitat. The toothcup is an obligate wetland species that is found in a wide range of wetland types. It is most common along the eastern seaboard, but its range extends west to the eastern great plains. The toothcup has been reported from a temporary pool about 6 km east of Boulder. These species are all obligate or facultative wetland species, and although several wetland areas have been identified at the RFP (EG&G 1990a), none of these areas is located within OU11. Wet areas around OU11 will be surveyed for the presence of these species.

Wetlands at the RFP were identified in conjunction with the National Wetlands Inventory and field checked by U.S. Army Corp of Engineers personnel to verify their jurisdictional status. Areas officially designated as wetlands at the RFP include reaches of Walnut Creek and Woman Creek. These linear wetlands consist of emergent, intermittently flooded stream channels (wetland type PEMW; see U.S. FWS 1976). They are characterized by willows, cattails, and other obligate or facultative vegetation species.

9.2.3 Study and Reference Areas

9.2.3.1 Study Area

The study area for the OU11 EE is defined to include habitats that could potentially have been affected by OU11 contaminants either through direct spray application or through the migration of contaminants from the sprayed areas. The selection of the OU11 study area was made on the basis of the review of environmental data, historical information on site use, and preliminary site visits in July and November 1991. The extent of the OU11 study area, shown in Figure 9-1, includes all of IHSS 168 and areas of the North Walnut Creek and Woman Creek drainages. The habitats included in this area, also shown in Figure 9-1, include mesic mixed grassland in the spray field itself and various riparian shrubland and disturbed areas along each of the drainages.

9.2.3.2 Reference Area

Reference areas can be used to assess impacts to the biological population or community levels, and to determine whether contamination at a site has led to uptake of potentially toxic contaminants into biological tissues. The decision to use reference areas and the process for selecting reference areas ultimately depend on the ecological endpoint or analytical endpoint to be measured. For ecological sampling, there should be scientific data on the effects of a contaminant on the endpoint in question and acceptable methods for measuring the endpoint. The decision process for using reference areas to assess ecological data is illustrated in Figure 9-5. Reference areas may also be used to determine whether site-specific conditions have lead to abnormally high levels of a particular contaminant in ecological receptors. Reference areas may be used for analysis of contaminant loads when ARARs for contaminant concentrations in tissues are not available or for determining whether contaminant loads have resulted from a particular site. The decision process for use of reference areas to assess tissue contaminant data is illustrated in Figure 9-6, and described further in Section 9.3.1.

Reference areas were selected for use in assessing ecological endpoints such as richness, species composition, and plant cover (Figure 9-5) (See Section 9.5 for endpoints to be assessed). Selection was based on criteria in SOP 5.13, Development of Field Sampling Plans. Briefly, reference areas for terrestrial sites were chosen on the basis of habitat type (see SOP 5.11, Identification of Habitat Types), soil series (from Soil Conservation Service map of Jefferson County), and topography, including slope and aspect. Reference areas for aquatic sites were selected on the basis of substrate, flow regime, depth, current, and bank characteristics. Reference areas for tissue sampling have the additional requirement of being located upgradient of, or otherwise remote from, the potential contaminant sources.

Reference areas were selected for the mesic mixed grassland habitat type that dominates terrestrial sites in OU11, and aquatic sites which include Woman Creek and Walnut Creek. These areas, located in the Rock Creek drainage (Figure 9-7) approximately 1 km north of OU11, were used as reference sites for the OU1 and OU2 EEs conducted in 1991. Data collected during these studies indicate that the reference areas are similar to OU11 in terms of dominant vegetation, topography, and soils. Because these sites are also considered as outside the potential zone of contamination for any of the operable units at the RFP, they can also serve as reference sites for the tissue collection program.

One of the major differences between Rock Creek reference areas and the mesic mixed grassland at OU11 is in historical land use. The Rock Creek areas have been undisturbed since grazing was halted about 60 years ago. The OU11 area was used for spray evaporation during operations until 1985. The additional moisture lead to apparently higher total ground cover and primary production during spray application, as evidenced from aerial photos taken during spray application. It is possible that the added moisture may also have led to differences in species composition which persist. In addition, a gravel quarry is located approximately 200 m to the west of OU11. The extensive physical disturbance associated with such operations could impact OU11 by serving as a seed source for aggressive weedy species common to disturbed areas.

9.3 PRELIMINARY RISK ASSESSMENT

9.3.1 Contaminants of Concern

9.3.1.1 Selection Criteria for Contaminants of Concern

Contaminants of Concern (COCs) are chemicals which are: (1) associated with activities at a hazardous waste site, (2) suspected to occur in environmental media as a result of activities at the site, and (3) have the potential to damage natural populations or ecosystems. In this context, chemicals include organic compounds, inorganic compounds, and elements. The list of COCs is used to select target analytes for testing biota and/or environmental media for contamination.

Identification of COCs for each EE shall be made on the basis of documented occurrence in environmental media, ecotoxicity, and the extent of contamination. These criteria are described in more detail below.

1. <u>Occurrence</u>

The known or suspected occurrence of a chemical in environmental media should be gleaned from:

a. existing data from abiotic media (soil, water, air) or biota;

b. waste stream identification and disposal practices;

c. process analyses to identify potentially hazardous substances used in large quantities; and

d. historical accounts of use or accidental releases.

The resulting list of chemicals shall then be evaluated for ecotoxicity and the extent of contamination at the site.

2. Ecotoxicity

For purposes of compiling the list of COCs, the ecotoxicity of a chemical is determined from its documented adverse effects on biota other than humans or livestock, or potentiation of the toxic effects of other chemicals. Toxicity data drawn from studies with laboratory animals may be considered. A chemical is considered for inclusion in the list of COCs if, at levels detected within the OU, it exhibits:

a. acute and chronic toxicity, including mortality and teratogenicity;
b. sublethal toxicity, including carcinogenicity, reduced growth rates, reduced fecundity, and behavioral effects;

c. toxicity resulting from bioaccumulation as a result of absorption of the chemical directly from environmental media or ingestion of contaminated food items.

The above information may be extracted from federal or state regulatory guidelines, chemical information data bases, or scientific literature. The resulting list of chemicals shall then be evaluated for extent of contamination at the site.

3. Extent of Contamination

The extent of contamination should be such that it results in significant exposure of ecological receptors. A chemical may be included in the list of COCs if:

a. it is present above natural background concentrations;

b. it is present above regulatory standards or ARARs;

c. it is present above risk-based "acceptable levels"; and

d. it is reported in greater than 5 percent of the samples analyzed for a given area.

and one or more of the following:

e. it is widely distributed;

f. it occurs in ecologically sensitive areas, such as wetlands or seeps which may serve as a water source for wildlife; and

g. it occurs in localized areas of high concentration.

A chemical is considered to be "widely distributed" if its occurrence is not restricted to one sample site. For example, if a chemical is known to occur in three different sample sites, it would be defined as widely distributed. On the other hand, a chemical would not be widely distributed if it occurred in three samples from the same site.

Chemicals that satisfy the above criteria of occurrence, ecotoxicity, and extent of contamination shall then be included in the list of COCs for the EE.

4. Additional Factors

Contaminants may become differentially distributed among environmental media or among components within a medium, depending on their physical and chemical properties. The result may be differential bioavailability or exposure of species or populations to the contaminant. The factors affecting distribution in environmental media include:

° Persistence -- the resistance to degradation by abiotic or biotic processes;

° Volatility -- the tendency to move from a solid or liquid medium into the atmosphere, thus reducing soil or water concentration;

° Mobility -- the degree to which a chemical tends to migrate within or between environmental media, thus placing additional receptors at risk;

- Solubility -- the degree to which a chemical enters or remains in aqueous solution which affects its mobility in surface water and groundwater and may influence its behavior in soil or sediment; and

- Differential accumulation -- the tendency to segregate into different environmental media or components of a single medium.

These factors should be considered when developing a target analyte list for analyses of specific organisms, tissues, or abiotic media.

Target analytes are COCs for which biological tissue will be analyzed to determine contaminant loads. To be considered a target analyte, a chemical included in the COCs must be known or suspected to bioaccumulate but in biological tissue. Alternatively, the effects of the chemical must be known and measurable using standard methods.

Selection of the species and specific tissues for analysis will be based on a preliminary evaluation of site-specific food webs, potential contaminant transport pathways, and potential for accumulation in specific organs or tissues. The decision process for conducting tissue analyses is presented in Figure 9-6. Analysis of tissues for contaminant loads will only be conducted for those COCs which bioaccumulate. A contaminant may not bioaccumulate may be known to cause predictable biochemical, physiological, or morphological effects in exposed organisms. For example, a chemical may be altered by physiological mechanisms, and therefore not found in high concentrations in the body. However, a metabolite of the original chemical may accumulate, or the chemical may lead to other metabolic effects such as increases or decreases in the level of certain enzymes or metabolic intermediates. Tissues will only be analyzed for such residual effects if standard methods exist for quantifying them. Whole body burdens or individual tissues may be analyzed depending upon which portions are consumed by organisms in higher trophic levels. Suitability of a species for tissue sampling will depend upon its position in the food web and its abundance at the site. Selection of target taxa is described in Section 9.3.2.

Where ARARs (i.e., acceptable levels in receptor species or prey species) are established, tissue sampling need only be conducted at the study area and not in reference areas. Where no applicable ARARs exist, tissue sampling will include suitable reference areas. The decision process for the use of reference areas in tissue sampling is shown in Figure 9-6. Use of statistical tests will be consistent with DQOs and quality assurance provisions of the QAPjP and DQOs.

To the extent possible, the above criteria have been applied to the potential contaminants at OU11. The results are summarized in Table 9-4. Final identification of COCs will be made when data are available to evaluate the extent of contamination at OU11. Availability of these data will allow evaluation of the factors listed under Criterion 3 (Table 9-4).

9.3.1.2 Toxic Nature of Contaminants

No criteria are available for metal contamination in terrestrial ecosystems. Human health-based "environmental action criteria" are available in the RCRA Facility Investigation Guidance Document (U.S. EPA 1989d) for carcinogens and noncarcinogens in the soils ingestion pathway for humans. Based on the assumption that the most sensitive species are 100 times more sensitive than humans, a safety factor of 100 was applied to the criteria listed in Table 9-2. However, most of these criteria were developed for specific metal, whereas most of the soils data for OU11 are based on total metal concentrations.

It has been determined on the basis of available information that the metals of greatest concern at OU11 are lead, arsenic, and mercury. Each of these metals was found above background concentration in soils at OU11, is known to be toxic, and tends to bioaccumulate or biomagnify. For reasons discussed in Section 9.2.1.2, the nature extent of contamination was difficult to assess from the available data. However, it is possible that the compounds were present in spray water and, therefore, may be localized to sprayed areas. Lead, mercury, aluminum, and zinc have known phytotoxicity. One mechanism of toxicity of these metals is through inhibition of vital enzyme activity (Larcher 1980). The enzymes affected are diverse but are mainly involved in derivation of energy or storage products. Selenium may also be of concern as it was also present in spray water and is known to be toxic to aquatic organism when leached from irrigated soils. Results from Phase I soil sampling are required to establish selenium levels in environmental media.

Unlike other types of contaminants, radionuclides have the potential to affect living organisms not in physical contact with the chemical. This requires much higher dosages than are typically encountered in radioactive contamination of environmental media. The greatest danger results from internalization of radionuclides. Many studies have addressed the potential for radionuclides to biomagnify or bioaccumulate. Cesium-137 resulting from fallout has been shown to concentrate up to nine-fold in some food webs. Generally, however, the data indicate that most radionuclides tend to bind tightly to soils and sediments and are not very available to biota. Thus, bioconcentration factors (BCFs) for transuranics are low. Little et al. (1980) found that plutonium was not accumulated in the food web in the grassland ecosystem at the RFP.

Acetone, chloroform, and toluene were detected in soils, but the concentrations were well below the environmental action criteria listed in Table 9-2. Acetone and toluene were also detected in groundwater. While there is no history of their disposal at OU11, detection of pesticides, PCBs, or dioxins would warrant their inclusion in COCs for this EE. The levels of these compounds in soils are below the specified action levels, but they are included in the preliminary list until further data indicate otherwise.

Nitrate is considered for inclusion in COCs because of its potential impact on surface waters and groundwater. High nitrate concentrations can lead to premature eutrophication of aquatic habitats and subsequent loss of diversity. However, high soil nitrate concentrations can also be indicative of disturbance of nutrient cycling due to the effects of other contaminants. Cyanide is also considered due to its potential impacts to surface water quality and to aerobic soil microbes and aquatic organisms.

9.3.1.3 Potential Exposure Pathways

A site conceptual model for OU11 is presented in Section 2.0. The model is a qualitative description of the nature and distribution of potential contaminants as well as possible mechanisms and pathways for off-site migration of those contaminants. One task of the EE is to identify actual or potential pathways by which biota may be exposed to site-specific contaminants. Each pathway model must include the following four elements:

1. A chemical/radionuclide source and mechanism of release to the environment;

2. An environmental transport medium (e.g., soil, water, air) for the released chemical/radionuclide;

3. A point of potential biological contact with the contaminated medium; and

4. A biological uptake mechanism at the point of exposure.

The exposure pathways described below will be further characterized using results of abiotic media sampling and environmental fate and transport modeling. These results will then be used in refining the biological tissue collection program and to determine the need for further ecotoxicological testing.

Contaminants at OU11 appear to be distributed primarily in soils and groundwater. However, leaching of contaminants from soils or off-site migration of contaminants via groundwater and erosional processes could lead to exposure of biota in surface water and sediments in areas downgradient of Woman Creek or Walnut Creek. Surficial soil samples will be of prime importance for determining source contaminants for biota. This uppermost layer is a major source of nutrients and contaminant uptake for vegetation and is also a potential source of contaminant ingestion by wildlife. As noted in Section 9.2.1.2, possible contamination of surficial materials warrants careful consideration. Soil samples from all depths may be related to surface water and groundwater regimes. Fluids moving through the soils can leach contaminants and transport them through available flow paths into downgradient environments. Contamination in soil and groundwater at a depth greater that 20 feet (maximum depth of burrowing animals and plant root penetration) will not be considered to affect biota.

Fauna using the areas in and around OU11 may be exposed to contaminants in abiotic media, including surface water, sediment, or soil. However, according to available data, these exposures are unlikely to result in acute toxicity. Results of the investigation of nature and extent of contamination in abiotic media performed during this Phase I RFI/RI is needed to confirm this conclusion.

The major pathways of concern involve contaminants that tend to bioaccumulate in biological tissues, resulting in potentially hazardous concentrations in exposed organisms. Organisms at risk are those that accumulate a contaminant through direct absorption from contaminated media, or that ingest contaminated media or contaminated food items. Ingestion of contaminated media may occur by drinking contaminated water or incidental ingestion of contaminated soil or sediment while feeding or drinking. Ingestion of prey or vegetation that themselves have accumulated contaminants can result in exposure of organisms in higher trophic levels, such as grazers and predators, that are not at risk due to exposure to environmental media alone. Such food web interactions will be considered in the risk assessment.

On the basis of the preliminary results of current studies, the top predators in the food webs at the RFP are raptors and coyotes. These large, wide-ranging species can be observed in nearly every part of the RFP. The prey base for these species consists primarily small mammals, with insects and smaller birds included in their diets. Because all of these predators hunt areas much larger than OU11, they can be exposed to contaminants from sites other than OU11. They therefore will not be collected in initial sampling directed at tissue analysis and quantification of exposures through food web interaction. Instead, sampling efforts will concentrate on the prey base and its food sources, which are more likely to be restricted to OU11. However, the use of OU11 by larger predators will be assessed and considered during the exposure assessments conducted later.

The top predators in aquatic systems are centrarchid sunfish (e.g., bass, green sunfish), that feed primarily on smaller fish, insects, and crayfish. Birds and mammals feeding on aquatic organisms provide a pathway from aquatic to terrestrial systems. Piscivorous birds at the RFP include double-crested cormorants, great blue herons, black-crowned night herons, and some raptors. Several species of ducks occur at the RFP and may be exposed through contaminated prey and algae, as well as incidental ingestion of contaminated water and sediment.

9.3.2 Target Taxa

9.3.2.1 Selection Criteria for Target Taxa

Contaminants can produce adverse effects at all levels of ecological complexity: individuals, populations, communities, and ecosystems. Contaminants can also threaten critical habitats and endangered species. Consideration of the effects of contaminants at either the individual or ecosystem level will not generally lead to the selection of specific taxa for analysis. Selection criteria for target taxa should therefore reflect primarily the population and community levels of ecological complexity.

Some selection criteria are essential, while others must be considered in context. For example, a threat to a single individual of an endangered species or to a critical habitat can be important. A threat to many individuals from an abundant population at a lower trophic level may not be important. A threat to many individuals in a population can produce secondary adverse effects on related species, which consequently impact community and ecosystem processes.

The two purposes for selecting target taxa are to: (1) assess contaminant effects on biota, and (2) measure contaminant concentrations in biota. Target taxa for RIs at the RFP are identified as assessment endpoints, measurement endpoints, or both. For taxa selected as measurement endpoints, additional criteria distinguish those sampled by destructive techniques (e.g., analyzed for contaminant concentrations or histopathological effects) from those sampled solely by nondestructive techniques (e.g., population surveys).

Other taxa of concern selected for specific nondestructive measurement must be potentially affected by the COC, have a reasonable home range relative to the area of contamination, and meet at least one of the following criteria:

a. be endangered, threatened, or otherwise protected (e.g., be a candidate species for federal listing or state protected species);
b. be economically important (e.g., a game or pest species); and
c. be important in the structure and function of the ecosystem, including but are not limited to taxa that:
   - serve as important food species for higher trophic levels,
   - provide habitat for other species in the ecosystem, and
   - function as top predators in the food web.

These criteria will be considered during analysis of data to determine specific impacts at the population or community levels.

Taxa for destructive sampling must potentially be affected by the COC in a manner that can be measured in tissues, have a reasonable home range with respect to the potential contamination, and meet all of the following criteria:

a. not be an endangered or threatened species;
b. have a population sufficient to support collection without producing direct adverse effects; and
c. be known to accumulate the particular COC or to demonstrate its effects in a manner that can be assessed by tissue sampling.

The process of selecting target taxa will involve determining the COCs for a particular geographic area of concern (e.g., an OU) and their characteristics relevant to the biota present in the area. If the contaminant bioaccumulates, food web analysis will be indicated. Food web analysis can focus on key species to be sampled for individual or population effects and can identify intermediate species in the food web that are appropriate for destructive analysis. If a contaminant is known to produce only phytotoxic effects, primary effects such as loss of plant cover can be measured directly, and secondary effects such as loss of habitat can be addressed for particular species. Species subjected to habitat loss also serve as measurement endpoints for secondary effects. Species losses (or impairments) that affect ecosystem-level processes may produce changes in microbial biomass or mineral concentrations in soil or water. All of these consequences will be considered in selecting the taxa for analysis on the basis of the criteria stated above.

9.3.2.2 Selection of Target Taxa

Target taxa for the OU11 EE will be selected based on the above criteria and the COCs, when identified. The matrix presented in Table 9-5 is used to summarize the species that satisfy the criteria for a given contaminant. As an example, target taxa were identified for lead and mercury (Table 9-6). In animals, both metals can cause acute and chronic toxicity, and tend to bioaccumulate. The concentration of these metals in biological tissues are commonly measured. Chronic toxicity is manifested in enzyme imbalance in liver and nervous tissue. Production of cholinesterases, a group enzymes involved in neural transmission, is inhibited by both enzymes. The activity of several liver enzymes are affected by lead exposure. Established methods are available for measurement of these enzyme activities in biological tissues.

Although many species may satisfy the criteria (Table 9-5), not all species will be collected for tissue analysis. The species identified as primary choices for collection and analysis will be chosen based on their abundance and relative importance in the OU11 community. Occasionally, species on the primary list may be unavailable at a given transect. In these cases, plans for contingencies will be made on the basis of the relative abundance of taxa at the sites sampled. For example, vegetation substitutions could be made according to the following sequence:

Primary Target Taxa	Substitute
Grasses:	
big bluestem	little bluestem
blue grama	prairie junegrass
Canada bluegrass	prairie junegrass
Forbs:	
Louisiana sage	hairy golden-aster
western ragweed	hairy golden-aster
blazing-star	broom butterweed
false gromwell	annual sunflower

The taxa identified in Table 9-6 were selected on the basis of the results of similar selections made for other EEs conducted at RFP. This list is subject to change when results of Task 3 field investigations are considered.

9.3.3 Development of the Field Sampling Plan

The Field Sampling Plan (FSP) helps to ensure that data and sample collection are consistent with the information objectives and Data Quality Objectives (DQOs) developed for the EE. The FSP presented in Section 9.5 is designed to be flexible so that preliminary data and information can be used to modify and refine subsequent sampling efforts. Data and sample collection methods will be consistent with the Ecology SOPs (Volume 5.0) (EG&G 1991e), and overall sample design will be consistent among tasks. Therefore, results from preliminary sampling in Task 3 will be compatible with subsequent sampling in Task 9.

9.3.3.1 Data Quality Objectives

The development of DQOs for this EE followed the three-stage process recommended by EPA (1989d):

- Stage 1 - Identify decision types
- Stage 2 - Identify data uses and needs
- Stage 3 - Design data collection program

The process for developing DQOs for the OU11 Phase I RFI/RI is described in detail in Section 4.0 of this work plan. A summary of the process as it was applied to the EE is presented below.

A. Stage 1 - Identify Decision Types

1. **Identify and involve data users** -- Decision makers and primary and secondary data users at the RFP are defined in Section 4.0.

2. **Evaluate available data** -- Analytical data from past soil sampling activities studies were rejected for use in evaluating nature and extent of contamination and for quantitative risk assessments (See Section 4.0). Available data were used to provide guidance in scoping work for the Phase I RFI/RI and to provide a qualitative description of the site. However, additional data are needed to characterize the physical setting and contaminants at OU11. Phase I RFI/RI activities planned to obtain these data are described in Section 7.0.

No previous studies at OU11 collected data specifically for a quantitative Human Health Risk Assessment or for evaluation of risks to ecological receptors. Only baseline qualitative data and quantitative data from other locations at the RFP are available for characterization of the ecological setting at the site. The plan for collection of data needed to characterize the ecological setting and assess risks to the environment is described in Section 9.5.

3. **Develop Site Conceptual Model** -- A site conceptual model was developed and presented in Section 2.0. Potential pathways for the exposure of biota to WSF contaminants are discussed in Section 9.3.1.3, above. Briefly, exposure to contaminated surficial soil via dermal contact or ingestion are the main pathways. Bioconcentration and bioaccumulation are also of concern, and food web analyses will therefore be conducted.

4. **Specify EE objectives and data needs** -- The specific objectives of the OU11 EE are to:

   - Determine whether contamination in physical media at OU11 has resulted in acute or chronic toxicity to biota through direct exposure;

   - Determine whether significant exposure to contaminants at OU11 has or could result from bioaccumulation via absorption or ingestion of environmental media (bioconcentration) or ingestion of food items that have bioaccumulated contaminants (biomagnification);

   - Determine the biological receptors that are potentially impacted by OU11 contamination;

° Determine the need for further ecological studies of chemical impacts at OU11; and

° Evaluate remediation needed to protect the environment.

B. Stage 2 - Identify Data Uses and Needs

1. **Identify data uses** -- The data to be collected under the EE will support the environmental risk assessment and the characterization of the ecological setting.

2. **Identify data types** -- Characterization of the ecological setting will entail collection of field data to quantify the ecological communities in the study area. Ecological data will be collected in the form of field observations as well as samples collected for laboratory analysis. Collection of all data will follow SOPs established for ecological sampling and data management.

3. **Identify data quality needs** - Qualitative and quantitative data will be required for comparisons of ecological community parameters between study and reference sites. The methods to be used are described in the Ecology SOPs (Volume 5.0). The standard methods described are suggested in EPA guidance for conducting ecological assessments. Field screening techniques will be used to assess some environmental parameters. Tissue samples collected for analysis of contaminant loads may require Level V CLP (as described in Section 4.0) special analytical services. Standard methods are available for analysis of the potential contaminants at OU11. However, non-standard methods for sample preparation may be needed.

4. **Identify data quantity needs** - Data quantity needs are dependent upon the objective of the sampling, the method used, and the random variability encountered. Replicate samples will be used in all cases. Replicates will consist of independent samples taken from sites within a given section of the study area. The sampling areas are based on ecologically functional units such as habitats within OU11, and the areas of direct spray application. The number and spatial distribution of sites within the sampled area depend on the size and geometry of the area. Terrestrial sampling will be conducted at sites selected for vegetation sampling. If size permits, ten vegetation sites will be established for each habitat to be assessed. Small mammals, large mammals, birds, and terrestrial arthropods will be sampled at five, randomly selected vegetation sites. Spray Areas 2 and 3 are too small to be sampled for the more mobile animals, and so ecological endpoints will be assessed only for vegetation. Tissue sampling, if found to be necessary will be conducted for Spray Areas 2 and 3.

5. **Evaluate sampling/analysis options** -- As in the abiotic sampling program of this RFI/RI, the EE employs a phased approach for data collection and analysis. Ecological survey data gathered in Task 3 and data gathered in soil and groundwater sampling activities will be used to finalize analyte suites and sample locations for Task 9 tissue sampling and ecotoxicological testing. Many of the ecological survey methods are nonintrusive and therefore do not generate waste. Initial food web and abiotic pathway characterizations will provide the framework for a focused investigation of the distribution of contaminants in biota.

6. **Review of PARCC parameter information** -- The criteria for data usability in risk assessment in the EE are listed in Table 4.3. Precision and accuracy goals of analytical data will be derived from the GRRASP and the Quality Assurance Project

Plan (QAPjP) for the RFP. For nonanalytical data associated with characterization of the ecological community, precision, accuracy, and comparability will be achieved through strict adherence to the SOPs for data collection and handling. Field audits will be conducted to assure adherence to SOPs. The target completeness objective stated in Section 4.0 is 100 percent with a minimum of 90 percent acceptable. Representativeness of samples will be achieved through application of the DQOs and sample location described in the FSP (Section 9.5). The sampling program for each taxonomic group was designed to achieve the resolution needed to discern differences in community structure between areas of interest within OU11.

C. STAGE 3 - Design Data Collection Program

The Field Sampling Plan presented in Section 7.0 describes the analytical and Quality Assurance/ Quality Control (QA/QC) protocols that will be used to evaluate the nature and extent of contamination in abiotic media. The FSP described in Section 9.5 defines the sampling program that will specifically support the assessment of risks to the environment. The FSP describes in detail the methods, locations, and frequency of sampling efforts for the ecological characterization. It also prescribes techniques, preliminary locations, and sample handling requirements for tissue collection. Planning for the tissue collection program will be finalized in Task 8, pending results of soil and sediment sampling programs. However, laboratory sample preparation and analytical needs have been anticipated based on the COC screening described in Section 9.3.2.

9.3.3.2 Coordination With Other Programs

The activities associated with the OU5 (Woman Creek Priority Drainage) and OU6 (Walnut Creek Priority Drainage) are pertinent to this EE as OU11 is adjacent to both drainages. The FSP described in Section 9.5 was designed to integrate the sampling programs of the EEs for both OUs. This is particularly important in design of the aquatic surveys planned for OU11. The overlap with the OU5 and OU6 sampling programs is described in Section 9.5. Data from the OU1, OU2, and OU5 EEs and the Baseline Vegetation and Wildlife Survey was used to scope activities for this EE. To optimally utilize data from the site wide surface water monitoring program, aquatic sampling sites largely coincide with sites established for that program.

9.4 APPROACH

This plan presents a comprehensive approach to conducting the EE at OU11. This approach is designed to ensure that all procedures performed are appropriate, necessary, and sufficient to adequately characterize the nature and extent of environmental risk to biota under the "no action" scenario. Because little data is currently available on characterization of soil contamination at OU11, a phased approach is adopted for field data collection associated with this EE. The first phase entails ecological characterization of the flora and fauna at and around OU11. The second phase will include collection of biological tissue for chemical analysis and will proceed when data on soils contamination become available as a result of Phase I RFI/RI investigations. This phased approach is built into the ten-task model described below. Initial field investigations will be conducted under Task 3. Results of Task 3 activities, soil sampling, and other Phase I RFI/RI tasks will be used to identify COCs and target analytes, and to design the tissue sampling program. Tissue sampling and other ecotoxicological studies will then be conducted under Task 9.

The approach presented in this plan is adapted from the toxicity-based approach to the assessment of ecosystem effects (U.S. EPA 1989a,b). Actual or potential biological impacts at the population, community, and ecosystem levels will be assessed with the endpoints to be measured including those at the level of the individual organism or tissue, population, community, and the abiotic environment. The approach is based on standard risk assessment concepts whereby uncertainties concerning potential ecosystem effects are explicitly recognized and, where possible, quantified. This plan is designed to provide a focused investigation of the risks to biota resulting from contamination at OU11. The study is also designed to account for factors other than OU11-specific contamination as the source of apparent ecological or toxicological impacts. Three types of information will be used (U.S EPA 1989b):

Chemical: Establish the presence, concentrations, and variability of distribution of specific toxic compounds. This effort is to be conducted under the RFI/RI abiotic sampling program.

Ecological: Conduct ecological surveys to characterize the condition of existing communities and establish whether any adverse effects have occurred.

Toxicological: Perform toxicological and ecotoxicological testing to establish the link between adverse ecological effects and known contamination.

The implementation of EEs at the RFP currently comprises ten tasks. The ten tasks and their interrelationships are shown in Figure 9-7. The tasks define sets of activities to be completed but do not necessarily represent the sequence in which the activities are to be completed.

Tasks 1 and 2 entail preliminary planning activities, including initial scoping, study area definition, and review of environmental data; identification of COCs, Target Analytes, and

Target Taxa; and coordination with other RFI/RI and RFP activities. Data gaps are identified and program objectives and DQOs defined.

The FSP developed in Task 2 is implemented in Tasks 3 and 9. Task 3 will include an ecological field inventory to characterize OU11 biota and their trophic relationships. Field inventories will be conducted in late spring and summer to obtain quantitative data on community composition in terrestrial and aquatic habitats. Where appropriate, samples collected as part of the activity may be preserved for tissue analyses. Task 8 is reserved for planning of additional field sampling that may be indicated as a result of Task 3 activities. Task 9 activities include collection of biological tissue for analysis of contaminant loads. Further community characterization and toxicity studies may be indicated from results of Task 3. Additional ecological and ecotoxicological endpoints will be assessed only where acceptance criteria for demonstrating injury to a biological resource will be satisfied in accordance with regulations under the Natural Resource Damage Assessment Rule (43 CFR Subtitle 1, Section 11.62 [f]). Task 9 also includes validation of data collected from both tasks.

General contamination and exposure assessments are conducted in Tasks 4 through 7. Task 4 will entail compilation of toxicity literature and the toxicological assessment of potential adverse effects from contaminants of concern on key receptor species. This task will be performed in conjunction with Task 5. The objective of Task 5 is to develop site-specific pathways model(s) based on the ecological field investigation and inventory. This exposure-receptor pathways model will be used to evaluate the transport of OU11 contaminants to biological receptors. The pathways model is based on a conceptual pathways approach (Fordham and Reagan 1991) and will provide an initial determination of the movements and distribution of contaminants, likely interactions among ecosystem components, and expected ecological effects. This effort will be coordinated with those of investigations in other operable units to avoid duplication of effort and to ensure consistent data collection techniques and consistent assessment of environmental risk.

Task 6 will provide a characterization of the risk to ecological receptors caused by potential exposure to OU11 contaminants and a summary of risk-related data concerning the site. Determinations will be made as to the magnitude of the effects of contamination on OU11 biota. The actual or potential effects of contamination on ecological endpoints (e.g., species diversity, food web structure, productivity) will also be addressed. Depending on the DQOs and the quality of data collected, the contamination characterization will be expressed qualitatively, quantitatively, or as a combination of the two. If sufficient information is available, Task 6 may also include the preliminary derivation of remediation criteria. Development of these criteria will include consideration of: (1) federal and Colorado laws and regulations pertaining to preservation and protection of natural resources and (2) RCRA risk-based criteria (or other criteria; see Section 3.0) for concentrations of contaminants in environmental media.

Task 7 includes the identification of assumptions and evaluation of uncertainty in the environmental risk assessment analysis. Task 7 will also include identification of data needs to calibrate and validate the pathways models developed in Task 5.

The EE report will be developed during Task 10. Results from EE tasks will be summarized and evaluations presented. The results of risk analysis and remediation criteria will also be presented. Information on site environmental characteristics and contaminants, characterization of effects, remediation criteria, conclusions, uncertainty analysis, and limitations of the assessment will be summarized in the EE report. A suggested outline for the report is presented in Section 1.2.10.

9.4.1 Tasks Completed To-Date

Tasks 1 and 2 are largely complete as a result of the preparation of this work plan. Preliminary field surveys were conducted in July and November 1991 to identify and delineate habitats, determine dominant vegetation, and identify physical features such as abandoned spray equipment, bermed areas, and areas of obvious physical disturbance or contamination. The boundaries of the study area and other areas potentially affected by OU11 contamination were also identified on the basis of these field visits. In addition, taxa to be collected for tissue analysis were identified. The FSP for ecological characterization was then developed in conjunction with the plans for soil sampling activities described in Section 7.0. The FSP is presented in Section 9.3. The results of these findings are discussed further in sections 9.1.2, 9.1.3, and 9.1.4. Preliminary screening of potential contaminants for inclusion in the COCs was also conducted (see Section 9.2.2). However, soils data collected previous to this Phase I RFI/RI are not sufficient to adequately characterize nature and extent of contamination. Therefore, finalization of COCs and subsequent selection of target analytes will be conducted when results of initial sampling of abiotic media are known. If necessary, final plans for tissue collection will be included in the FSP as part of Task 8 planning for Task 9 field activities.

9.4.2 Remaining Tasks

The principal activities remaining in Tasks 1 and 2 include further literature review and site characterization. These will be conducted in conjunction with the Task 3 Ecological Field Investigation. Information that will be developed from these tasks includes the following:

- Contaminants of concern -- Data collected during abiotic sampling will be reviewed and used to select COCs and target analytes.

- Descriptive field surveys -- An inventory of OU11 biota and locations of obvious zones of chemical contamination, ecological effects, and human disturbance will be compiled.

- Species inventory -- An inventory of the plant and animal species known to occur within OU11 or to potentially contact contaminants will be compiled as a result of the preliminary field investigations and the Task 3 surveys.

- Population characteristics -- The composition of ecologically functional groups and the abundance of dominant species in those groups will be documented.

- Food habit studies -- Available information from literature sources will be used to supplement field observations and if necessary, gut content analysis on target species.

Ecological site characterization will be refined using information collected during Task 3 studies. The purpose of the site characterization is to describe resource conditions as they exist without remediation. The narrative with supporting data will include descriptions of each resource, with attendant tables and figures as appropriate, to depict, in a concise and clear fashion, site conditions, particularly as they influence contaminant fate and transport.

A preliminary community food web model will be developed to describe the trophic interactions potentially important to exposure pathways at the site. The model will be used to identify species at risk of exposure to toxic contaminant levels in forage or prey. Food web construction begins with gathering information to evaluate the food habits of species (e.g., grasshoppers) found or potentially occurring on the site. Standard computer searches will be augmented with searches of local university libraries to locate any regionally pertinent studies on food habits. The preliminary list of important species, compiled from background information, will be completed on the basis of observations on presence and abundance made during the ecological site surveys and on trophic level data obtained from the food web model. On the basis of the model, a modified list of species will be made using toxicological information (toxicity assessment) to determine which species or species groups might be most affected by or most sensitive to COCs.

Data from past studies and preliminary data from current environmental studies will be used to better define the present distribution of contaminants from the abiotic environment and to develop an initial food web model. The food web model will be used in conjunction with a preliminary pathways analysis to identify likely or presumed exposure pathways or combinations of pathways and receptor species at risk. Based on this preliminary information, the Task 3 and Task 9 field investigation sampling approach/designs may be revised.

9.4.2.1 Task 3: Ecological Field Investigation

Field surveys will be conducted in Task 3 to characterize current biological site conditions in terms of species composition, habitat characteristics, and/or community organization. The emphasis will be to describe the structure of the biological communities at OU11 in order to identify present biological impacts, potential contaminant pathways, and important ecological receptors. Field activities are detailed in the FSP (Section 9.5).

The objectives of the Task 3 field activities are to include the following:

1. Identify protected habitats or species present.

2. Gather data for inventory, habitat use, and relative abundance assessments of OU11 flora and fauna to support final selection of target species and food web pathway analysis.

3. Collect samples for tissue analysis where COCs and target species have been identified from Task 1 and 2.

4. Collect data for additional ecological endpoints identified from Tasks 1 and 2.

Vegetation Sampling

The objectives of the vegetation sampling program are to provide data for: (1) the description of site vegetation characteristics, (2) identification of potential exposure pathways from contaminant releases to higher trophic-level receptors, (3) selection of key taxa or life-forms for contaminant analysis to determine background conditions for OU11, and (4) identification of any protected vegetation species or habitats. On the basis of preliminary data from July 1991, OU11 is dominated by mesic mixed grassland habitat , predominately Canada bluegrass and mountain mule. Riparian shrubland habitat borders the northern edge of OU11 and includes species typical of slightly wetter soil conditions. A section of the northern portion of OU11 was bermed to prevent water from running into Walnut Creek and to promote infiltration. Vegetation in these sections are typical of highly disturbed soils. These areas will be surveyed and assessed separately.

Terrestrial Wildlife Sampling

Terrestrial wildlife will be surveyed to assess habitat use by large, wide-ranging animals such as deer, coyotes, and raptors as well as to determine relative abundance of small mammals and birds that may be more restricted to OU11. Habitat use information is important for exposure assessment because different activities result in different levels of exposures. Use of OU11 by wide-ranging animals also represents pathways by which effects of OU11 contaminants can reach beyond the boundaries of the OU. Potential prey species such as small mammals and insects may not be affected but may accumulate contaminants to levels that may result in adverse impacts to predators.

Aquatic Sampling

Aquatic habitat at OU11 is limited to upper reaches of Woman Creek, which lie to the south of OU11, and the headwaters of Walnut Creek, which is intermittent along this section. Aquatic sites in the Walnut Creek and Woman Creek drainages could be threatened by migration of OU11 contaminants in groundwater and erosional runoff. These drainages will be assessed for potential adverse impacts to biota from such migration. However, both streams are ephemeral in these reaches and community structure is likely to be dominated by the lack of persistent flow. In addition, the nearest persistent sections of both streams are located downstream from other potentially contaminated sites. Therefore, quantitative characterization of aquatic communities is unlikely to reveal impacts attributable only to OU11 contaminants. Quantitative ecological characterization of Walnut Creek will be conducted during the OU4 and OU6 EEs. Likewise, characterization of Woman Creek is under way as a part of the OU1, OU2, and OU5 EEs. These data will be reviewed for use in the OU11 EE. Collection of aquatic biota will be integrated with site wide surface water and sediment monitoring programs and other RFI/RI activities. Therefore, aquatic sampling during the OU11 EE will be limited to qualitative assessment of community composition and tissue collection from study and reference areas. If insufficient biomass is available for tissue sampling, in-situ tests using crayfish or mollusks may be used to assess the potential for bioaccumulation of OU11 contaminants.

Tasks 4 through 7 comprise the contamination assessment. The two major objectives of the contamination assessment are to:

1. Obtain quantitative information on the types, concentration, and distribution of contaminants in selected species.

2. Evaluate the effects of contamination in the abiotic environment on ecological systems.

Contamination assessment requires an evaluation of chemical and radiological exposures and the actual or potential toxicological effects on target species. Specifically, the assessment should identify exposure pathways, exposure points within each pathway, contaminant concentrations at those points, and potential impacts or injury.

The contamination assessment will be made on the basis of existing environmental criteria, published toxicological literature, and existing site-specific data. The assessment will also draw on data resulting from other ongoing RFI/RI studies so that concentrations of contaminants in abiotic media can be related to biota exposures. Development and refinement of this model will be an iterative process. The model will be used to determine tissue sampling requirements in Task 8, then be refined using the results of that analysis.

9.4.2.2 Task 4: Toxicity Assessment

This assessment will include a summary of potential adverse effects on biota associated with exposure to OU11 contaminants, the relationship between estimated exposure concentrations relative to reference doses (RfDs) or published values with known toxic effects, and an uncertainty analysis of the above for this site. Potential health effects on ecological receptors will then be characterized using EPA critical toxicity values (when available) in addition to selected literature pertaining to site-specific and receptor-specific parameters. The toxicity assessment will include brief toxicological profiles for COC. The profiles will cover the major health effects information available for each COC. Data pertaining to wildlife species will be emphasized, and information on domestic or laboratory animals will be used when wildlife data are unavailable.

9.4.2.3 Task 5: Exposure Assessment and Pathways Model

The objective of this task is to assess abiotic and biotic pathways by which ecological receptors may be exposed to OU11 contaminants. Present exposures will be assessed, as well as the potential for future exposures if no remedial action in taken (i.e., the "no action scenario"). In addition, future-use scenarios assessed in the Human Health Risk Assessment (HHRA) will also be assessed for impacts to ecological receptors.

Each pathway will be described in terms of the chemical(s), media, and potential receptors involved. Each exposure assessment includes the following three components:

- exposure pathways;
- exposure points and concentrations; and
- estimated chemical intake by receptors.

The assessment of exposure pathways described in Section 9.3.1.3 will be refined on the basis of data collected in Task 3 of this EE, the results of abiotic media sampling, and the results of contaminant fate and transport modeling. In abiotic pathways, exposure points are the locations where receptor species may contact the COCs. In biotic pathways, the exposure point(s) is the contaminated food items.

For abiotic pathways, results of fate and transport modeling of contaminant concentrations and movements will be used to assess exposure points and concentrations. Data on abiotic media from other Phase I activities and site wide programs will be used to characterize source areas and release characteristics at the site. Exposure assessments will also be coordinated with those of the HHRA. Exposure points and concentrations associated with biotic pathways will be estimated from food web modeling and actual measurements of tissue contaminant loads, if conducted.

Contaminant uptake by target species will be evaluated on the basis of the routes of contaminant uptake by target species. Potential mechanisms of uptake include direct routes (such as inhalation, ingestion of contaminated media, or dermal contact) and indirect routes (such as ingestion of prey species that have been contaminated). The metabolic fate of a contaminant is also important in determining the ultimate exposures. Contaminants that tend to bioaccumulate can result in exposure to much higher concentrations than possible from the environmental media alone. Exposures will be evaluated using published BCFs and site-specific data. The amounts of chemical and radiological uptake will be estimated using site-specific analytical data and forthcoming guidance from EPA's Wildlife Exposure Factors Handbook (to be published in 1991).

Exposures estimates will vary depending on both the contaminant and the target species under consideration. Factors that influence exposure through a given pathway include:

- Major routes of exposure;
- Organisms actually or potentially exposed to contaminants from OU11;
- Concentrations of each contaminant to which organisms are actually or potentially exposed;
- Frequency and duration of exposure;
- Seasonal and climatic variations in conditions that may affect exposure; and

° Site-specific geological, physical, and chemical conditions that may affect exposure.

Two scenarios will be evaluated. The worst-case scenario will be based on assumptions that foraging species obtain all of their food from OU11 habitats, and that all food items contain the maximum contaminant load detected. The second scenario will factor best estimates of the habitat use by foraging species and the distribution of the contaminant in the population of food or prey. Best estimates will be used because accurate determination of these parameters would require efforts beyond the scope of this Phase I investigation. The need for such estimates will be assessed based on the risk assessments and quantified uncertainties resulting from this Phase I investigation.

9.4.2.4 Task 6: Contamination Characterization

Characterization of adverse effects on receptor populations or the ecological community (non-destructive endpoints) is generally more qualitative in nature than characterizing human risks because the toxicological effects of most chemicals have not been well documented for most species. Criteria that are suitable and applicable for the evaluation of ecological effects are generally limited. EPA Ambient Water Quality Criteria (AWQC) and Maximum Allowable Tissue Concentrations (MATC) are the most readily available criteria. Criteria found in federal and Colorado state laws and regulations pertaining to preservation and protection of natural resources can also be used. Criteria may also be derived from information developed for use under other environmental statutes, such as the Toxic Substances Control Act (TSCA) or the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). In accordance with EPA guidance (1989c,d), priority will be placed on the adverse effects of chemicals on populations and habitats rather than on individuals. Where specific information is available in published literature, a more quantitative evaluation of effects will be made using the site-specific pathways model. This approach is in agreement with EPA guidance (U.S. EPA 1989a).

Contamination characterization entails integrating exposure concentrations and reasonable worst-case assumptions with the information developed during the exposure and toxicity assessments to characterize current and potential adverse biological effects (e.g., death, diminished reproductive success, reduced population levels) posed by OU11 contaminants. The potential impacts from all exposure routes (inhalation, ingestion, and dermal contact) and all media (air, soil, groundwater, and surface water/sediment) will be included in this evaluation as appropriate according to EPA guidance (U.S. EPA 1989a).

9.4.2.5 Task 7: Uncertainty Analysis

The process of assessing ecological effects is one of estimation under conditions of uncertainty. To address uncertainties, the OU11 EE will present each conclusion, along with the issues that support and fail to support the conclusion, and the uncertainty accompanying the conclusion. Factors that limit or prevent development of definitive conclusions will also be discussed. In summarizing the assessment data, the following sources of uncertainty and limitations will be specified:

- Variance estimates for all statistics;
- Assumptions and the range of conditions underlying use of statistics and models, and
- Narrative explanations of other sources of potential error.

Validation and calibration of the pathways model will also be used where practicable.

9.4.2.6 Task 8: Planning

Task 8 will include planning for tissue analysis studies and any additional ecotoxicological studies needed to assess adverse effects from the COCs on receptor species. Planning for the Task 8 field investigations will begin after COCs and target species have been selected in Task 2.

The need for measuring additional ecotoxicological endpoints in Task 8 will be evaluated on the basis of the pathways analyses and published information on direct toxic effects. Selection of field methodologies will be made on the basis of a review of available scientific literature providing quantitative data for the species of concern or similar test species. Analysis of population, habitat, or ecosystem changes will be based on species or habitats that represent broad components of the ecosystem or that are especially sensitive to the contaminants. In order to select methodologies for the ecotoxicological field sampling program, the biological response under consideration and the proposed methodology should satisfy program DQOs as well as the following more specific criteria:

1. The methodology and measurement endpoint must be appropriate to the exposure pathway. The biological response to the contaminant is well-defined, easily identifiable, and predictable.

2. The contaminant is known to cause the biological response in laboratory experiments or experiments with free-ranging organisms.

3. The available sample size is large enough to have useful power and minimize Type II error.

Tissue analyses will be conducted for selected aquatic and terrestrial species from OU11 and reference areas. Toxicity testing methods are available for terrestrial ecosystems using microbes and earthworms (U.S. EPA 1989a,b). Although their use is not anticipated, the need for such tests will be evaluated according to the above criteria as part of this planning process.

Prior to conducting Task 8 studies, the FSP will be refined to address the proposed methodologies. More specific DQOs will be formulated on the basis of the proposed methodologies and will address the following:

- Number and types of analyses;
- Species, locations, and tissues to be sampled;
- Number of samples collected;
- Detection limits for contaminants; and
- Acceptable margin of error in analyzing results.

Collection of samples for tissue analyses will comprise most of the Task 9 ecotoxicological field investigation. Analysis of tissue contaminant concentrations will provide data to evaluate the relationship between environmental concentrations and contaminant loads predicted by pathway and food web models.

To the extent possible, tissue samples will be collected simultaneously with environmental media samples collected during other Phase I RFI/RI sampling activities. This will allow for determination of site-specific BCFs, which will then be incorporated into the exposure assessment and will be used to calibrate/validate the pathways model. Where BCFs cannot be determined, published, or predicted, BCF values will be used in the pathways model to assess potential impacts.

Additional ecotoxicological studies indicated from results of Tasks 4 and 5 may include in-situ (in-field) toxicity testing and/or further laboratory toxicity testing. These tests can be used to isolate specific contaminants or sources. Selection of a particular methodology is generally made on the basis of the method's capability to demonstrate a measurable biological response to the selected COCs.

9.4.2.7 Task 9: Ecotoxicological Field Investigation

The revised FSP developed in Task 8 will be executed in Task 9. SOPs and analytical requirements will be closely adhered to. Reference areas will be sampled in parallel to study areas to help ensure comparability of data. Results of Task 9 activities may be used to revise contamination assessment and pathways models. If necessary, further sampling may be done.

9.4.2.8 Task 10: Environmental Evaluation Report

Task 10 will include the summary of information and production of an EE report as part of the RFI/RI report. The EE report will be prepared in a clear and concise manner to present study results and interpretation. All relevant data from the EE, in addition to relevant Phase I RFI/RI data, will be integrated and evaluated in the characterization of potential environmental impacts. The following topics will be covered in the report:

- Objectives;
- Scope of Investigation;
- Site Description;
- Contaminants of Concern and Target Species;
- Contaminant Sources and Releases;
- Exposure Characterization;

- Impact Characterization;
- Remediation Criteria; and
- Conclusions and Limitations.

A more detailed proposed outline of the report is shown in Table 9-7.

Remediation criteria protective of the RFP biota will also be developed in Task 10 on the basis of the results of the food web analyses, pathways model, and exposure assessments. Remediation criteria will be developed for contaminants for which a significant ecological impact is detected or for which that risk exists. Criteria will address remediation of the contaminant source so that remaining environmental concentrations do not pose a threat to key ecological receptors. "Acceptable" environmental concentrations will be estimated using exposure assessments to calculate contaminant concentrations in abiotic media below which the ecotoxicological effect does not occur. The acceptable (no-effects) criteria levels will be used in conjunction with ARARs to evaluate potential adverse effects on biota as appropriate for the EE portion of the Phase I RFI/RI. This approach will be integrated with the Human Health Risk Assessment process and will assist in development of potential remediation criteria.

9.4.2.9 Schedule

The schedule for completion of this EE is presented in Table 9-9. Many of the ecological field activities must be completed during a specific time of year. Initial preparation for field work should begin in late winter with ecological sampling beginning the following April. Activities may have to be rescheduled if funding for the implementation of this EE work plan does not allow field work to begin in the spring.

9.5 FIELD SAMPLING PLAN

9.5.1 Purpose and Scope of the Field Sampling Plan

The purpose of this FSP is to provide a study design and schedule that will satisfy the DQOs described above. This FSP describes the technical approach and sampling methodology to be used as well as the location and number of sample sites and the frequency of data collection. COCs, target taxa, and target analytes and the processes by which they were chosen are also described herein.

Field sampling will be conducted as parts of Tasks 3 and 9 of this EE. Task 3 will include brief field surveys to determine occurrence, distribution, and relative abundance for an ecological inventory of OU11. This data will be used to identify target species, development of the food web, and pathways models for later contamination and risk assessment. Task 9 will include tissue sampling and analysis for selected COCs, and measurement of any additional ecological endpoints identified during contamination assessment tasks. Planning for the Task 9 tissue analysis program will begin in Task 2 so that samples collected in the Task 3 field inventory can be used wherever possible (i.e., where contaminants of concern have been defined and field sampling protocol have been developed). Final determination of the need for additional ecotoxicological studies (e.g., reproductive success, population studies, or enzyme analyses) will be made after completion of the contamination assessment.

The objectives of the field sampling program are to:

- Confirm habitat identification and delineation (Figure 9-1);
- Identify protected habitats or species present;

- Gather data for inventory and relative abundance assessments of OU11 flora and fauna;
- Assess toxicity of abiotic media to exposed organisms;
- Collect samples for tissue analysis where COCs and target species have been identified from Task 1 and 2; and
- Collect data for additional ecological endpoints where identified from Tasks 1, 2, and 8.

9.5.2 Sampling Approach

9.5.2.1 Sampling Locations

Study Areas

Study areas for OU11 include the following:

- The sprayed areas included in IHSS 168
- Areas of the Walnut Creek and Woman Creek drainages potentially downgradient of IHSS 168

Details of the OU11 study area are discussed in Sections 9.2.2 and 9.2.3. Sample sites were selected in areas of OU11 that could potentially have been impacted by previous disturbance or contamination but that presently support or are used by terrestrial or aquatic organisms. This includes sites within and adjacent to IHSS 168 as well as sites at varying distances downgradient and upgradient. Where necessary, data collection will be stratified by habitat type to ensure that apparent differences or trends are not merely related to habitat. IHSS 168 is composed largely of one habitat type, mesic mixed grassland. Therefore, within IHSS 168 data collection will be stratified by functional area. That is, sprayed and unsprayed areas will be assessed separately. Vegetation will be characterized for each sprayed area. However, the areal extent of Spray Areas 2 and 3 is too small to conduct independent assessment of ecological endpoints for fauna. Therefore, these areas will be assessed together. Tissue collection, if necessary, will be conducted separately for Spray Areas 2 and 3. Spray Area 1 will be assessed as a unit.

Ecological and analytical endpoints will also be assessed for areas within IHSS 168, but outside the sprayed areas. These areas are potentially unaffected by spray application and will be used to determine the extent of risk to biota within IHSS 168. These areas will be sampled in addition to the reference areas outside the IHSS.

Approximate sites for vegetation surveys are shown in Figure 9-10. Fauna sampling sites are collocated with vegetation sampling sites. Identification and delineation of habitats presented in Figure 9-1 were in accordance with SOP 5.11, and location of sample sites within each habitat followed specific procedures outlined in the appropriate taxon-specific SOPs (SOPs 5.1 - 5.10).

Reference Areas

Details of the proposed reference areas are discussed in Section 9.2.3. Reference sites will be used as one basis for evaluating community, population, or habitat impacts and tissue contaminant loads potentially associated with OU11 contamination. Reference areas for each of the major habitat types found in the OU11 study area (xeric grassland, mesic grassland, and riparian woodland) have been selected. In addition, a reach of a small tributary to Rock Creek has been identified as a reference area for aquatic sampling. These include areas to the north of the plant site, in the Rock Creek and North Walnut Creek drainages (Figure 9-7). The areas to the north are generally considered to be upgradient from the plant and outside the zone of impact and therefore will be used as reference areas for ecological comparisons and collection of biological tissue for analysis of contaminant loads. Specific sampling sites in reference areas will be identified on the basis of further site visits and results of sampling conducted under the OU1 and OU2 EEs. The number of sample sites in the reference areas will be the same as the corresponding habitats within the OU11 study area.

Reference areas were selected on the basis of the parameters cited in SOP 5.13. Briefly, reference and study areas should be of the same habitat type and be similar in habitat size, dominant vegetation, slope and aspect, and soil type. Other factors considered were historical land use and proximity to the study area.

Differences Between Study Areas and Reference Areas

Differences between study areas and reference areas can confound comparisons between the two. Important differences are discussed in Section 9.2.3 and have been accounted for in the selection process.

9.5.2.2 Habitat and Taxon-Specific Sampling

The field program includes sampling for both ecological and analytical parameters. Although the programs for both sampling activities are described herein, sampling biological tissue for contaminant analysis will occur only after COC and target analytes have been identified. The endpoints, collection methods, and collection times are summarized in Table 9-8.

Terrestrial Sampling

The objective of data and sample collection in terrestrial habitats will be to gather data for construction of food web and exposure pathways models. Relative abundance and distribution will be assessed for all major groups of terrestrial organisms. However, collection of samples for tissue analysis will be limited to small mammals, arthropods, and vegetation. Preliminary identification of terrestrial sampling locations is presented in Figure 9-9. The sampling locations include each of the three major sprayed areas (Areas 1, 2, and 3).

Soil will be sampled under the abiotic media sampling program. Under this program, nitrates will be analyzed in surficial and deeper soils.

Vegetation (SOP 5.10)

Rationale and Endpoints -- Vegetation will be sampled to determine community composition, dominant taxa, woody plant and cacti diversity, production, and to collect tissue for analysis. Data and sample collection and sample preservation will follow procedures described in SOP 5.10. Spring and summer community data will be collected, and tissue samples will be collected in late summer and early fall. Ecological data will be collected for each of the major vegetation mapping units found in OU11. Samples will be located within a mapping unit according to the procedures in SOP 5.10. Sampling locations will coincide with the RFI/RI soil sampling locations where practicable and will include samples from each of sprayed areas at OU11. Tissue samples will be collected from areas of suspected contamination and from reference areas, if appropriate. Sample size adequacy in cover and biomass surveys will be determined using Cochran's formula (Cochran 1977). Sample sites will be located within a mapping unit in accordance with the procedures in SOP 5.10. Tissue samples will also be collected from these areas and from reference areas, as appropriate.

Data collected along the vegetation transects will be used to assess the following ecological endpoints:

- Total plant cover;
- Cover by perennial grasses, annual grasses, perennial forbs, annual or biennial forbs, woody plants, and cacti;
- Cover by individual species;
- Richness (number of species);
- Density (for woody plants and cacti);
- Production (standing biomass in grams [g]/m^2); total and by species;
- Height (in centimeters [cm]); and
- Tissue contaminant load (if necessary).

In assessing vegetation cover, a minimum of ten 50-m transects will be sampled in each sampling unit in the study and reference areas, unless precluded by limited areal extent. Variability of results will be assessed (using Cochran's formula; see SOP 5.10), and further samples collected, if necessary. Production in each habitat will be assessed by clipping the aboveground biomass from within five 0.5-m^2 plots along each of at least five transects within each habitat. Sample adequacy will be assessed for cover data with an upper limit of 30 transects. Tissue sampling will entail collection of target species within belt transects (see SOP 5.10). At least three, but not more than six, 30-g samples of each target species will be collected from designated transects. Tissue will be collected from at least five transects within each habitat.

<u>DQOs</u> -- DQOs for vegetation community sampling are to collect to statistical adequacy for quantitative comparisons between sampling units within the IHSS and between study sites and reference sites. For herbaceous cover and production sites, an 80 percent level of confidence

in calculated means is sought, but not more than 30 transects will be sampled from a given habitat. At least 25-g fresh weight will be collected for analysis of tissue contaminant loads. QA/QC will be provided through the sampling of replicates within a sampling unit. Mean values of each parameter for each site will be determined on the basis of these samples.

Terrestrial Arthropods (SOP 5.9)

Rationale and Endpoints -- Terrestrial arthropods (e.g., insects, spiders, ticks) will be surveyed for relative abundance, and composite samples will be collected for tissue analysis. Data will be used in exposure assessment for organisms in higher trophic levels. Sweep netting will be employed at sample locations that coincide with vegetation sampling locations in areas of suspected contamination and reference areas. Samples collected for taxonomic identification will be preserved in ethyl alcohol or by using the techniques appropriate to the taxon as indicated in SOP 5.9. Samples collected for tissue analysis will be preserved by freezing in accordance with SOP 5.9.

Assessment of community composition will include evaluation of the following endpoints:

- Richness (number of species collected from a given transect)
- Biomass (g/m^2 of selected taxa collected from transect)

Orthopterans, mostly grasshoppers, will be emphasized in collection of specimens for tissue analysis. In grassland habitats, this group consists primarily of ground-dwelling species, and relatively large numbers can be obtained. Thus, grasshoppers are good candidates for analysis of the biological fate of soil contaminants. Grasshoppers will be collected using sweep nets. Sample locations will coincide with vegetation sampling locations in the IHSSs and other areas of known contamination. If insufficient sample biomass is collected along a given transect(s), the adjacent area will also be swept.

DQOs -- DQOs for arthropod sampling are to collect data for quantitative comparisons of species richness between sampling units within the IHSS and between study sites and reference sites. Sweep-net surveys provide data on richness and qualitative assessment of abundance. A minimum of 25 g (fresh weight) of sample is sought for tissue analysis. One sample was collected per transect or area. QA/QC is provided through the sampling of replicates within a sampling unit. Mean values of each parameter for each site will be determined on the basis of these samples.

Birds (SOP 5.7)

Rationale and Endpoints -- Bird surveys will be conducted to determine use of OU11 habitats by potential avian receptors. Data will be used in development of pathway models and exposure assessments. Surveys will be conducted according to the procedures described in SOP 5.7. Sampling will be conducted in Spray Area 1, Spray Areas 2 and 3 combined, unsprayed areas in IHSS 168, and in reference areas. Songbird surveys will be conducted in the spring, and raptor observations will be conducted throughout the study. Songbird surveys will consist of three to eight 100-m by 100-m census plots in each habitat and will be conducted on four mornings during the breeding season in accordance with procedures described in SOP 5.7. Endpoints to be considered include:

- Density (number per hectare [ha]) by species; and
- Richness (number of species);

Qualitative data will also be collected during surveys in more limited riparian habitats during the breeding season and in grassland habitats during nonbreeding seasons. These "relative abundance" surveys will also yield information on species richness and numbers but will not be amenable to statistical analysis.

DQOs -- DQOs for bird surveys are to collect data for quantitative comparisons of species richness and density between specified sampling units within the IHSS and between study sites and reference sites. The number of plots counted in a given habitat will be as at least three with more if space or geometry allows. QA/QC is provided through the sampling of replicates within a site. Mean values of each parameter for each site will be determined on the basis of these samples.

Small Mammals (SOP 5.6)

Rationale and Endpoints -- Small mammal populations will be surveyed to determine habitat use and relative abundance. The data will be used in development of pathway models and exposure assessment. Small mammals will be collected in accordance with the live-trapping techniques described in SOP 5.6. Trapping configuration depends upon the configuration of the habitat. Grids, 25 traps x 25 traps, will be used within IHSS 168. Lines of 25 traps placed at 5-m intervals will be used along drainages. Traps will be set for four consecutive nights in early and late summer. Sampling will be conducted at five sites in each sampling unit. Each site will be collocated with a vegetation site. Spray Areas 2 and 3 will be sampled as a unit.

For community evaluation, endpoints include:

- Richness (number of species);
- Abundance (number per trap-night) by species;

- Mean weight;
- Weight - length (head and body) ratio; and
- Sex (age, reproductive activity).

It is anticipated that samples of 25 g will be required for tissue analysis. Some species weigh less than 25 g, and multiple individuals may be required to complete one sample. Samples collected for tissue analysis will be frozen in certified clean glass jars and will be composited as needed. Samples will be collected from all small mammal sampling locations in the study.

DQOs -- DQOs for small mammal surveys are to collect data for quantitative comparisons of species richness and abundance between specified sampling units within the IHSS and between study sites and reference sites. For ecological endpoints (e.g., richness, abundance, density), at least four sites will be sampled in each habitat. Therefore, data from each habitat includes at least four replicates. Mean values of each parameter for each site will be determined on the basis of these samples. At least 25 g per sample will be required for tissue analysis. QA/QC is provided through the sampling of replicates within a site. At least three, but not more than six, 25-g samples of each species will be collected from each site.

Large Mammals (SOP 5.5)

Rationale and Endpoints -- The relative abundance and distribution of large mammals, such as deer, coyotes, and jackrabbits, will be assessed to gain information about use of OU11 areas by these species. The resulting data will be used in construction of food web models and exposure assessment. Data collection will follow the procedures described in SOP 5.5. Fecal pellet counts will be conducted in five vegetation-belt transects in each sampling unit within

IHSS 168. Surveys will be conducted in spring and fall. The use of reference areas is not anticipated. The endpoint will be:

- Number of fecal pellet groups per unit area (m^2, ha)

In addition, relative abundance transects will be established across Spray Areas 1, 2 and 3 combined and along the Walnut Creek drainage north of IHSS 168. Surveys will be conducted in spring and fall. Relative abundance surveys include observations of wildlife in general, not just large mammals. These data will be used in assessing use of the OU11 areas by Rocky Flats wildlife. These data will not be appropriate for statistical analysis.

<u>DQOs</u> -- The DQOs for large mammal surveys are to determine the species that use IHSS 168 habitats and the frequency of use. For pellet counts, QA/QC is provided through the sampling of replicates within a site. Mean values of each parameter for each site will be determined on the basis of these samples.

Reptiles and Amphibians (SOP 5.8)

<u>Rationale and Endpoints</u> -- OU11 contains no permanently wet areas, but anurans (frogs) and uropods (salamanders) will be surveyed when water is present in drainages during spring and fall. Frogs will be surveyed by chorus surveys, salamanders by minnow traps in temporary pools. Data will be used in food web models and exposure assessments. Relative abundance data are considered qualitative. Garter snakes and rattle snakes may be collected for tissue analysis if necessary. Tissue samples will consist of whole animals, with at least three samples collected for each area.

DQOs -- Data on occurrence of herp species at the RFP is sought for use in food web models and exposure assessments. Tissue samples will consist of at least 25 g wet weight. Data on abundance or density will be used in such models but will be considered qualitative.

Aquatic Sampling

Aquatic habitat at OU11 is limited to upper reaches of Woman Creek, which lie to the south of OU11, and the headwaters of Walnut Creek, which is intermittent along this section.

Assessing the impacts of OU11 contaminants to the aquatic community structure along Woman Creek would be difficult for two main reasons. First, OU5 includes areas between OU11 and Woman Creek and it would be difficult to identify impacts due to specifically to OU11 contaminants in this area. Second, this area of Woman Creek is near the headwaters, and the stream community structure changes rapidly with stream size. Differentiation of community structure changes due to natural factors from those due to OU11 would require an effort beyond the risk assessment scope of an EE.

Quantitative ecological assessment of Walnut Creek is not likely to yield useful results either. The section of the Walnut Creek drainage immediately adjacent to OU11 is intermittent, creating a harsh environment for aquatic organisms and resulting in high natural variability in community structure in the stream. Further, the nearest persistent reach of Walnut Creek downstream of OU11 is also downstream of other OUs and from sites of recent construction (700 Building parking lot).

Sampling at surface water sites on Woman Creek relevant to this EE was conducted during the aquatic surveys associated with the OU1, OU2, and OU5 EEs. The sampling program for these EEs was designed to allow differentiation of contamination due to each of the OUs that border on Woman Creek. When available, this data will be considered before final design of the aquatic sampling in Woman Creek for the OU11 EE. Sampling for the OU11 EE will be limited to qualitative assessment of species richness and composition, and collection of biological tissue. In addition, data from the OU1, OU2, and OU5 EEs will be reviewed and used in this assessment.

Toxicity tests were conducted in 1991 for Woman Creek and its tributaries in conjunction with EEs for OU1 and OU2 in 1991. Results showed limited toxicity to *Ceriodaphnia* sp. of water from surface water stations on Woman Creek. However, water from "background" stations also showed some toxicity. It is not clear whether aquatic toxicity testing associated with the OU11 EE will yield results attributable to OU11 contamination. Similarly, aquatic toxicity testing at Walnut Creek sites may not yield unequivocal results. Aquatic toxicity testing is planned as a part of the OU6 (Walnut Creek Priority Drainage) and should yield results that will allow distinction of toxicity due to possible contaminant input from OU4 (Solar Evaporation Ponds). Therefore, aquatic toxicity testing associated with OU11 will be conducted only after data from other OUs are analyzed.

Stations to be sampled in the aquatic program include established surface water monitoring stations on both Walnut Creek and Woman Creek. Stations on Woman Creek include SW107, SW040, and SW041. Stations further downstream on Woman Creek include areas sampled extensively under other EEs. Tissue may be collected from these sites only if contaminants specifically attributable to OU11 are analyzed. Stations on persistent sections of Walnut Creek include SW093 and SW117, both downstream of OU11. SW117 is upstream of the 700 Building parking lot; SW093 is just downstream of the parking lot, but upstream of possible input from OU4 (Solar Evaporation Ponds). These samples will be used for collection of tissue if necessary. SW081 and SW082 are located within OU11 but are not permanent water bodies. Sampled areas will include a 50-m stream reach, 25 m upstream and downstream of the selected sample station. Samples will also be collected from a section of a Rock Creek tributary. This section is indicated in Figure 9-7.

Benthic Macroinvertebrates (SOP 5.2)

Rationale and Endpoints -- Benthos is composed mainly of the aquatic stages of some insects, adult insects, and snails. Qualitative surveys will be conducted using Surber samplers or by examination of substrate. If enough biomass is present, composite samples of selected taxa will be sampled for tissue analysis. Tissue analysis samples will likely be composed of aggregated insect larvae. Data will be used in contaminant pathway analysis and fate and transport modeling. Samples will be collected by hand or by use of a Surber sampler or equivalent. Endpoints assessed will include:

- Species occurrence;
- Richness; and
- Contaminant load.

DQOs -- Samples collected for tissue analysis should be at least 25 g (fresh weight). Three replicate samples are sought from each station sampled. QA/QC is provided through the sampling of replicates within a site. Mean values of each parameter for each site will be determined on the basis of these samples.

Fish (SOP 5.4)

Rationale and Endpoints -- The fish population will be qualitatively assessed for species presence and habitat use. Tissue samples will be collected pending identification of target analytes. Surface water stations in areas of persistent flow will be sampled. Minnow traps and hand seines will be the primary collection methods. Electroshocking may also be used if other methods prove inadequate. Endpoints assessed will be:

- Species occurrence;
- Richness; and
- Tissue contaminant loads.

DQOs -- DQOs include qualitative assessment of species composition during spring and fall flows. The minimum sample needed for tissue analysis is three 25-g samples. QA/QC is provided through the sampling of replicates within a site. Mean values of each parameter for each site will be determined on the basis of these samples.

9.5.3 Contaminants of Concern and Ecological Receptors of Concern

9.5.3.1 Contaminants of Concern

Final selection of COCs and target analytes will be made when sufficient data on contamination of abiotic media are available. According to current IAG schedules, soil data should be available in late summer 1992. This data will be used to identify further ecological studies for Task 9 and to identify the target analytes for which biological tissues will be analyzed. The candidate chemicals and the process for selecting COCs and target analytes for the OU11 EE is discussed in Section 9.3.1.

9.5.3.2 Ecological Receptors of Concern (Target Taxa)

The target taxa for the OU11 EE were selected on the basis of the criteria described in Section 9.3.2, data from preliminary site surveys, and data from studies conducted during 1991. These selections are subject to change pending results of Task 3 surveys and food web analyses.

9.5.3.3 Selection of Tissues and Target Analytes

As discussed in Section 9.3.1, not all of the potential COCs will be appropriate for analysis in biological tissues. The data collected on tissue contaminant loads will be used to support exposure pathway analysis using food web models. The species chosen for analysis of contaminant loads are usually totally consumed by predators. Therefore, tissue analysis for the target analytes will consist of whole body or composite whole-body analysis.

9.5.4 Tissue Sample Collection and Analysis

Tissue collection and analysis will be conducted under Task 9. Planning for Task 9 will take place during Task 8. Target analytes, the chemicals for which samples will be analyzed, will be identified from the larger list of COCs. Final identification of COCs will occur when initial data from abiotic sampling programs is complete.

The objective of the tissue analysis program is to ascertain the extent to which OU11 contaminants have been taken up by flora and fauna in affected areas. Therefore, the objective of the tissue collection program is to collect biological tissue samples from which the distribution and level of contaminants in populations of the selected taxa. To do this, a minimum of three and maximum of six replicate samples will be collected from each area to be assessed. Tissue collection sites will coincide with sites surveyed for ecological characterization. For OU11, the candidate areas to be assessed include Spray Areas 1, 2, and 3; former bermed areas where spray water tended to pool; containment ditches; downstream sites on Walnut Creek and Woman Creek; and reference areas for each study area. The areas to be sampled may change pending results from abiotic sampling.

Sample handling will follow procedures designed to ensure sample quality. Disposable latex gloves will be used when handling specimens collected for tissue analysis and changed between samples. Samples will be preserved promptly and appropriately. Sample preservation methods and holding times are summarized in Table 9-9. To ensure that composited samples are unbiased representatives of the populations in question, procedures for compositing samples will include random or counterbalancing components. Samples will be assigned unique sample numbers consistent with the RFP RFEDS requirements. All RFP sample number assignment, handling, and shipping requirements detailed in SOP 1.0 will be adhered to strictly.

9.5.4.1 Terrestrial Samples

Sample Collection and Preservation

Small mammals, plants, and insects will be sampled according to the methods described in the SOPs. At least three but not more than six 25-g samples of each small mammal species will be collected from each area. Only one sample from each transect will be analyzed. Each sample should consist of 2-3 individuals captured from the same grid or transect. Grasshoppers will be collected to represent insects. Three 25-g composite whole-body samples will be collected for each area. Samples will consist of composited species. For plants, at least three but not more than six 25-g (wet weight) samples of each species will be collected from each area. Again, only one sample from each transect will be analyzed.

When an insufficient sample can be collected for a given species, substitute species identified from Task 3 surveys should be used.

Small mammal and insect samples will be frozen in clean glass jars. If no organic target analytes are identified, plant samples will be frozen in clean zip-lock bags. If organics are analytes, plants will be wrapped in hexane-rinsed aluminum foil, and frozen.

Chemical Analyses

The analytes for which the biological tissues are to be analyzed will be identified when data from analysis of abiotic media are available. SOPs for sample preparation and analytical methods await contractual negotiations with the analytical laboratories.

9.5.4.2 Aquatic Samples

Sample Collection and Preservation

Fish, crayfish, and larval insects will be collected from aquatic habitats for tissue analysis. Procedures utilized in collecting specimens for tissue analysis will follow those described in SOP 5.0, Ecology. Fish and crayfish will be frozen in clean glass jars or hexane-rinsed aluminum foil. Insects will be frozen in clean glass jars. As in terrestrial samples, a minimum of three 25-g samples of each species from each site is desired.

Chemical Analyses

The analytes for which the biological tissues are to be analyzed will be identified when data from analysis of abiotic media are available. SOPs for sample preparation and analytical methods await contractual negotiations with the analytical laboratories.

Table 9-1: Summary of Soils Contamination Data at West Spray Field

Analyte	Background[1]	Max Value Reported	Depth	Action Level[4]
Metals (mg/kg)				
Al	13,419.50	10,600[2]	6-12 inches	30[5]
Cr	20.00	14[2]	6-12 inches	III-80,000 VI-400
Fe	13,753.57	12,500[2]	0-6 inches	--
Pb*	12.15	63[2]	Surface scrape	--
Zn*	39.71	52[2]	Surface scrape	20-400
As*	4.30	9.2[2]	Surface scrape	--
Hg*	0.20	0.46[3]	2.2 feet	--
Radionuclides (pCi/g)				
gross Alpha*	38.364	55[2]	Surface scrape	--
gross Beta*	36.815	40[2]	Surface scrape	--
Pu^{239}	0.0150	0.15[2]	Surface scrape	--
Am^{241}	0.0135	0.05[2]	0-6 inches	--
$U^{233,234}$*	0.656	1.2[2]	Surface scrape	--
U^{238}*	0.683	1.2[2]	Surface scrape	--
H^3*	0.415	0.54[2]	6-12 inches	--
Inorganics (mg/kg)				
Nitrate (as N)*	0.85[6]	420[3]	4.0 feet	--
Organics (µg/kg)				
Acetone*	DL	89[3]	4.2 feet	$8x10^6$
Chloroform*	DL	27[2]	6-12 inches	$110x10^3$
Toluene*	DL	43[2]	0-6 inches	--

*Exceeds background

[1]Source: EG&G 1990c. (Values are the upper tolerance intervals for alluvial borehole samples)
[2]1986 soil sample
[3]1988 soil sample
[4]Source: U.S. EPA 1989d. (Values listed are the human health-based "environmental action criteria divided by 100 based on the assumption that the most sensitive species is 100 times more sensitive than humans)
[5]Action criteria for Al-phosphide
[6]Mean concentration

Table 9-2: Summary of Possible Groundwater Contamination at OU11

Analyte	Background	Max. Values Reported
Metals (mg/ℓ)		
Ca	0.003[1,2]	0.02[4]
Pb	0.002[1,2]	0.10[4]
Al	0.083[1,2]	0.83[4]
Inorganics (mg/ℓ)		
Cyanide	--	0.113[4]
Nitrate (as N)	2.17[1,3]	6.5[4]
Radionuclides (pCi/ℓ)		
$U^{233+234}$	--	1.97[4]
Organics (μg/ℓ)		
Toluene	DL	5[4]
Acetone	DL	11[4]

DL = Detection limit
[1]Source: EG&G 1990c. Background Geochemical Characterization Report for 1989
[2]Mean value, no upper tolerance limit available
[3]Upper tolerance limit
[4]Source: EG&G 1991c. 1990 Annual RCRA Groundwater Monitoring Report for Regulated Units

Table 9-3: Summary of Possible Surface Water Contamination, OU11

Analyte	Background (mean ±SD)[1]	Station	Max. Values Reported
Dissolved Metals and Inorganics (mg/ℓ)			
Al	0.121±0.083	SW006*	0.45
		SW107*	0.20u
		SW041*	0.20u
		SW093*	0.68
As	0.0049±0.0021	SW006*	0.01u
		SW107*	0.01u
		SW041*	0.01u
		SW093*	0.01u
Cyanide	0.0046±0.0077	SW006*	0.040
		SW107*	0.010
		SW041	0.0010
		SW093	
Hg	0.0002±0.0002	SW006	0.0002u
		SW107	0.0004
		SW041	0.0004
		SW093	0.0005
Nitrate	0.82±0.404	SW006	0.30
		SW107	0.39
		SW041	0.29
		SW093	--
Pb	0.0027±0.0017	SW006*	0.005u
		SW107*	0.0055
		SW041*	0.006u
		SW093*	0.005u
Se	0.0027±0.0017	SW006	0.005u
		SW107	0.0086
		SW041	0.005u
		SW093*	0.055

Dissolved Radionuclides (pCi/ℓ)

		Max. Values Reported		
Analyte	Background[1,3]	SW006	SW007	SW041
Am^{241}	0.177	0.042	0.277*	ND
H^{3}	2022	500	280	170
Pu^{239}	1.46	ND	0.02	0.014
Sr^{90}	1.61	1.80*	0.67	0.60
$U^{233+234}$	1.105	0.30	1.10	1.50*
U^{238}	0.919	0.87	1.4*	0.4

*Exceeds background; u = present below detection limit; [1]Source: EG&G 1990c; [2]Source: EG&G 1991a; [3]Upper tolerance interval

Table 9-4: Selection Matrix for Contaminants of Concern, OU11

Analyte	Criterion 1 - Occurrence[1]							Criterion 2 - Ecotoxicity[2]					Criterion 3 - Extent of Contamination[3]												
	a	or	b	or	c	or	d	a	or	b	or	c	a	and	b	or	c	and	d	and	e	or	f	or	g
METALS																									
Aluminum	X							X																	
Arsenic	X							X																	
Chromium	X							X		X		X													
Lead	X							X		X															
Mercury	X							X		X		X													
Selenium	X							X		X		X													
Zinc	X																								
ORGANICS																									
Acetone	X						X																		
Methylene chloride	X																								
Chloroform	X		X																						
Toluene	X							X		X															

n/a - not applicable
NS - no standard or criterion available

[1]a. Existing data
b. Waste stream characterization
c. Process analysis
d. Historical data

[2]a. Acute or chronic toxicity
b. Sublethal toxicity
c. Bioaccumulates

[3]a. Above background concentration
b. Above ARAR for biota
c. Above risk-based level (soil and sediment)
d. Occurs in >5% of samples
e. Widely distributed (>20% of sample locations)
f. Occurs in ecologically sensitive area
g. Occurs in "hot spots"

Table 9-4: Selection Matrix for Contaminants of Concern, OU11

Analyte	Criterion 1 - Occurrence[1]							Criterion 2 - Ecotoxicity[2]					Criterion 3 - Extent of Contamination[3]												
	a	or	b	or	c	or	d	a	or	b	or	c	a	and	b	or	c	and	d	and	e	or	f	or	g
RADIONUCLIDES																									
Gross Alpha	X																								
Gross Beta	X																								
Americium-241	X		X							X															
Plutonium-239+240	X		X		X		X			X															
Strontium-90	X																								
Tritium	X		X				X																		
Uranium-233+234	X		X		X		X			X															
Uranium-238	X		X		X		X			X															
INORGANICS																									
Cyanide	X		X							X															
NO_3+NO_2	X		X				X			X															

n/a - not applicable
NS - no standard or criterion available

[1]a. Existing data
b. Waste stream characterization
c. Process analysis
d. Historical data

[2]a. Acute or chronic toxicity
b. Sublethal toxicity
c. Bioaccumulates

[3]a. Above background concentration
b. Above ARAR for biota
c. Above risk-based level (soil and sediment)
d. Occurs in >5% of samples
e. Widely distributed (>20% of sample locations)
f. Occurs in ecologically sensitive area
g. Occurs in "hot spots"

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
			AND	AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
VEGETATION - Forbs							
Alyssum	ALMI	X	E	X		X	X
Western Ragweed	AMPS	X	X L	X		X	X
Arnica	ARFU	X	E	X		X	X
Louisiana Sage, Cudweed Sagewort	ARLU	X	X M	X		X	X
Limber Vetch	ASFL	X	X M	X		X	X
Hoary Cress	CADR	X	M	X		X	X
False-flax	CAMI	X	E	X		X	X
Musk Thistle	CANU	X	M	X		X	X
Diffuse Knapweed	CEDI	X	E	X		X	X
Canada Thistle	CIAR	X	M	X		X	X
Field Bindweed	COAR	X	M	X		X	X
Horseweed	COCA	X	L	X		X	X
Wild Parsley	CYAC	X	E	X		X	X
Flixweed	DESO	X	E	X		X	X
Wallflower	ERAS	X	E	X		X	X
Filaree	ERCI	X	E	X		X	X
Spreading Fleabane	ERDI	X	E	X		X	X
Trailing Fleabane	ERFL	X	X M	X		X	X
Low Fleabane	ERPU	X	E	X		X	X
Curlycup Gumweed	GRSQ	X	X L	X		X	X
Common Sunflower	HEAN	X	M	X		X	X
Hairy Golden-aster	HEVI	X	X M	X		X	X
Common St. Johns-wort	HYPE	X	X M	X		X	X
Prickly Lettuce	LASE	X	X M	X		X	X
Bladder-pod	LEMO	X	E	X		X	X
Blue Flax	LIPE	X	E	X		X	X

E = Early Summer
M = Mid-Summer
L = Late Summer

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
			AND	AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
Blazing-star, Dotted Gayfeather	LIPU	X	X L	X		X	X
White Sweetclover	MEAL	X	X M	X		X	X
Yellow Sweetclover	MEOF	X	X M	X		X	X
False Gromwell	ONMO	X	X M	X		X	X
Lambert Locoweed	OXLA	X	E	X		X	X
Purple Prairie-clover	PEPU	X	X M	X		X	X
Scorpion-weed	PHNE	X	M	X		X	X
Slimflower Scurfpea	PSTE	X	X M	X		X	X
Prairie Coneflower	RACO	X	X M	X		X	X
Broom Butterweed	SESP	X	L	X		X	X
Tumbling Mustard	SIAL	X	E	X		X	X
Golden Banner	THDI	X	E	X		X	X
Goatsbeard, Salsify	TRDU	X	E	X		X	X
Moth Mullein	VEBL	X	M	X		X	X
Great Mullein	VETH	X	X L	X		X	X
VEGETATION - Graminoids							
Crested Wheatgrass	AGDE	X	M	X		X	X
Intermediate Wheatgrass	AGIN	X	M	X		X	X
Quackgrass	AGRE	X	E	X		X	X
Western Wheatgrass	AGSM	X	M	X		X	X
Big Bluestem	ANGE	X	X L	X		X	X
Red Three-awn	ARLO	X	X M	X		X	X
Side-oats Grama	BOCU	X	X M	X		X	X
Blue Grama	BOGR	X	X M	X		X	X
Smooth Brome	BRIN	X	M	X		X	X
Japanese Brome	BRJA	X	E	X		X	X
Cheatgrass	BRTE	X	E	X		X	X
Nebraska Sedge	CANE	X	M	X		X	X
Narrowleaf Sedge	CAST	X	X M	X		X	X

E = Early Summer
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Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
		AND		AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
Baltic Rush	JUBA	X	M	X		X	X
Prairie Junegrass	KOMA	X	X M	X		X	X
Canada Bluegrass	POCO	X	X M	X		X	X
Kentucky Bluegrass	POPR	X	M	X		X	X
Little Bluestem	SCSC	X	X L	X		X	X
Needle-and-thread	STCO	X	X M	X		X	X
Green Needlegrass	STVI	X	M	X		X	X
VEGETATION - Aquatic							
Hornwort	CEDE	X	X L	X		X	X
Mare's-tail	HIVU	X	X L	X		X	X
Water Milfoil	MYEX	X	X L	X		X	X
Water Cress	NAOF	X	X M	X		X	X
Yellow Cress	ROPA	X	X M	X		X	X
American Bulrush	SCAM	X	X L	X		X	X
Narrowleaf Cattail	TYAN	X	X L	X		X	X
Broadleaf Cattail	TYLA	X	X L	X		X	X
TERRESTRIAL INVERTEBRATES							
Grasshoppers		X	X	X		X	X
Ground Beetles		X		X		X	X
Ants		X		X		X	X
Mixed taxa from sweep net		X		X		X	X
AQUATIC INVERTEBRATES							
Aggregated Benthic Macroinvertebrates		X		X		X	X
Aggregated Nektonic Invertebrates				X		X	X
Plankton (Zoo- and Phyto-)		X		X		X	X

E = Early Summer
M = Mid-Summer
L = Late Summer

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

Taxon	Species Code	REQUIRED: Reasonable Home Range	AND: Sufficient Biomass to Collect	AND: Not Threatened or Endangered	AND AT LEAST ONE: Morphological Anomalies	OR: Chemical May Be in Tissue	OR: Effect May Be in Tissue
FISHES							
Stoneroller	CAAN1	X		X	X	X	X
White Sucker	CACO1	X	X	X	X	X	X
Green Sunfish	LECY1	X	X	X	X	X	X
Largemouth Bass	MISA1	X	X	X	X	X	X
Golden Shiner	NOCR1	X	X	X	X	X	X
Fathead Minnow	PIPR1	X	X	X	X	X	X
Creek Chub	SEAT1	X	X	X	X	X	X
AMPHIBIANS							
Tiger Salamander	AMTI1	X		X		X	X
Woodhouse's Toad	BUWO1	X		X		X	X
Northern Chorus Frog	PSTR1	X		X		X	X
Northern Leopard Frog	RAPI1	X		X		X	X
REPTILES							
Yellow-bellied Racer	COCO1	X		X		X	X
Western Painted Turtle	CRPI1	X		X		X	X
Prairie Rattlesnake	CRVI1	X	X	X		X	X
Short-horned Lizard	PHDO1	X		X		X	X
Bullsnake	PIME1	X		X		X	X
Eastern Fence Lizard	SCUN1	X		X		X	X
Wandering Garter Snake	THEL1	X		X		X	X
Western Plains Garter Snake	THRA1	X		X		X	X
BIRDS (Eggs, Nestlings)							
Cooper's Hawk	ACCO1					X	X
Spotted Sandpiper	ACMA1			X		X	X
Sharp-shinned Hawk	ACST1		X			X	X
Red-winged Blackbird	AGPH1	X	X	X		X	X
Grasshopper Sparrow	AMSA1	X		X		X	X

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
			AND	AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
Green-winged Teal	ANCR1			X		X	X
Cinnamon Teal	ANCY1			X		X	X
Blue-winged Teal	ANDI1			X		X	X
Mallard	ANPL1	X	X	X		X	X
Gadwall	ANST1			X		X	X
Great Blue Heron	ARHE1			X		X	X
Canada Goose	BRCA1			X		X	X
Red-tailed Hawk	BUJA1		X	X		X	X
Ferruginous Hawk	BURE1			X		X	X
Swainson's Hawk	BUSW1			X		X	X
Great Horned Owl	BUVI1			X		X	X
House Finch	CAME3	X	X	X		X	X
Lesser Goldfinch	CAPS1	X		X		X	X
American Goldfinch	CATR1	X	X	X		X	X
Belted Kingfisher	CEAL1			X		X	X
Lark Sparrow	CHGR1	X		X		X	X
Common Nighthawk	CHMI1			X		X	X
Killdeer	CHVO1	X	X	X		X	X
Northern Harrier	CICY1			X		X	X
Northern Flicker	COAU1		X	X		X	X
American Crow	COBR1			X		X	X
Rock Dove	COLI1			X		X	X
Yellow Warbler	DEPE1	X	X	X		X	X
Gray Catbird	DUCA1	X		X		X	X
Horned Lark	ERAL1	X		X		X	X
Brewer's Blackbird	EUCY1			X		X	X
American Kestrel	FASP1	X	X	X		X	X
American Coot	FUAM1			X		X	X
Common Snipe	GAGA1			X		X	X
Common Yellowthroat	GETR1	X	X	X		X	X
Blue Grosbeak	GUCA1	X		X		X	X

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
			AND	AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
Cliff Swallow	HIPY1		X	X		X	X
Barn Swallow	HIRU1			X		X	X
Northern Oriole	ICGA1	X	X	X		X	X
Loggerhead Shrike	LALU1	X		X		X	X
Song Sparrow	MEME2	X	X	X		X	X
Brown-headed Cowbird	MOAT1			X		X	X
Black-crowned Night Heron	NYNY1			X		X	X
Sage Thrasher	ORMO1	X		X		X	X
Black-capped Chickadee	PAAT1	X		X		X	X
House Sparrow	PADO1		X	X		X	X
Savannah Sparrow	PASA1	X		X		X	X
Double-crested Cormorant	PHAU1			X		X	X
Ring-necked Pheasant	PHCO1			X		X	X
Rufous-sided Towhee	PIER1	X		X		X	X
Black-billed Magpie	PIPI1		X	X		X	X
Downy Woodpecker	PIPU1			X		X	X
Vesper Sparrow	POGR1	X	X	X		X	X
Pied-billed Grebe	POPO1			X		X	X
Common Grackle	QUQU1			X		X	X
Rock Wren	SAOB1	X		X		X	X
Say's Phoebe	SASA1	X		X		X	X
Western Meadowlark	STNE1	X	X	X		X	X
European Starling	STVU1	X		X		X	X
American Robin	TUMI1	X		X		X	X
Eastern Kingbird	TYTY1	X		X		X	X
Western Kingbird	TYVE1	X		X		X	X
Warbling Vireo	VIGI1	X		X		X	X
Yellow-headed Blackbird	XAXA1	X		X		X	X
Mourning Dove	ZEMA1		X	X		X	X

Table 9-5: Criteria for Selecting Taxa as Destructive Measurement Endpoints, OU11

		REQUIRED			AND AT LEAST ONE		
			AND	AND		OR	OR
Taxon	Species Code	Reasonable Home Range	Sufficient Biomass to Collect	Not Threatened or Endangered	Morphological Anomalies	Chemical May Be in Tissue	Effect May Be in Tissue
MAMMALS							
Black-tailed Prairie Dog	CYLU1	X		X		X	X
Feral House Cat	FEDO1			X		X	X
White-tailed Jackrabbit	LETO1	X	X	X		X	X
Striped Skunk	MEME1			X		X	X
Prairie Vole	MIOC1	X	X	X		X	X
Meadow Vole	MIPE1	X	X	X		X	X
Long-tailed Weasel	MUFR1			X		X	X
House Mouse	MUMU1	X		X		X	X
Muskrat	ONZI1	X	X	X		X	X
Hispid Pocket Mouse	PEHI1	X		X		X	X
Deer Mouse	PEMA1	X	X	X		X	X
Raccoon	PRLO1			X		X	X
Western Harvest Mouse	REME1	X	X	X		X	X
Plains Harvest Mouse	REMO1	X	X	X		X	X
Desert Cottontail	SYAU1	X		X		X	X
Badger	TATA1			X		X	X

Table 9-6: Target Taxa To Be Analyzed for Tissue Contaminant Loads (Destructive Sampling), OU11

<u>Vegetation</u>	
Canada Bluegrass	(*Poa compressa*)
Mountain Muhly	(*Muhlenbergia montana*)
Big Bluestem	(*Andropogon gerardii*)
Little Bluestem	(*Schizachyrium scoparium*)
Blue Grama	(*Bouteloua gracilis*)
Louisiana Sage	(*Artemisia ludoviciana*)
Hairy Golden-aster	(*Heterotheca villosa*)
Western Ragweed	(*Ambrosia psilostachya*)
Blazing-star	(*Liatrus punctata*)
False Gromwell	(*Onosmodium molle*)
Broom Butterweed	(*Senecio spartioides*)
<u>Insects</u>	
Grasshoppers	(All)
<u>Small Mammals</u>	
Prairie Vole	(*Microtus ochragaster*)
Meadow Vole	(*Microtus pennsylvanicus*)
Deer Mouse	(*Peromyscus maniculatus*)
<u>Fish</u>	
White Sucker	(*Catostomus commersoni*)
Fathead Minnow	(*Pimephales promelas*)
Golden Shiner	(*Notemigonus crysoleucas*)
Creek Chub	(*Semotilus atromaculatus*)
Green Sunfish	(*Lempomis cyanellus*)
Largemouth Bass	(*Micropterus salmonoides*)
Stoneroller	(*Campostoma anomalum*)
<u>Benthos</u>	
Crayfish	(*Orconectes sp*)

Table 9-7: Proposed EE Report Outline -- West Spray Field (OU11)

EXECUTIVE SUMMARY

1.0 INTRODUCTION
- 1.1 Objectives
- 1.2 Site History
- 1.3 Scope of Evaluation

2.0 SITE DESCRIPTION
- 2.1 Physical Environment
  - 2.1.1 Air Quality/Meteorology
  - 2.1.2 Soils
  - 2.1.3 Surface Water
  - 2.1.4 Groundwater
- 2.2 Biotic Community
  - 2.2.1 Aquatic Community
  - 2.2.2 Terrestrial Community
  - 2.2.3 Protected/Important Species and Habitats

3.0 CONTAMINANT SOURCES AND RELEASES
- 3.1 Sources
- 3.2 Releases

4.0 CONTAMINANTS OF CONCERN
- 4.1 Criteria Development for Selection of Contaminants of Concern
- 4.2 Definition of Contaminants

5.0 TOXICITY ASSESSMENT
- 5.1 Toxicity Assessments of Contaminants of Concern
- 5.2 Contaminant Effects
  - 5.2.1 Terrestrial Ecosystems
  - 5.2.2 Aquatic Ecosystems

6.0 EXPOSURE ASSESSMENT
- 6.1 Contaminant Pathways and Acceptable Criteria Development
  - 6.1.1 General Methodology for Pathways Analysis
  - 6.1.2 Selection of Key Receptor Species
- 6.2 Exposure Point Identification
  - 6.2.1 Soil
  - 6.2.2 Water
  - 6.2.3 Vegetation
- 6.3 Chemical Fate and Transport

Table 9-8: Sampling Matrix, OU11

Taxa	Endpoints	SOP	Collection Methods	Collection Times
TERRESTRIAL				
Vegetation				
Ecological	C(s), C(t), P, R, D, Height, P/A	SOP 5.10	Pt. Intercept, Belt Transects	May-June, July-August
Tissue	Tissue Contaminant Concentration	SOP 5.10	Clipping	August
Small Mammals				
Ecological	R, A, Weight, Re, Sex, P/A	SOP 5.5	Live Trap Grid/ Lines	May-June, August
Tissue	Tissue Contaminant Concentration	SOP 5.5	Live Trap Grid/ Lines	August
Large Mammals				
Ecological	RA, Pellet Counts, P/A	SOP 5.6	Relative Abundance Pellet Counts	May-June, August-Sept., December
Terrestrial Arthropods				
Ecological	RA, R, P/A	SOP 5.8	Sweep Net, Pitfalls	May-June, August-Sept.
Tissue	Tissue Contaminant Concentration	SOP 5.8	Sweep Net, Pitfalls	May-June, August-Sept.
Birds				
Ecological	RA, R, D, P/A	SOP 5.7	Breeding Plots (Spring) Ehmlen Transects	May, August, December
AQUATIC				
Benthos				
Ecological	R (qualitative), P/A	SOP 5.2	Surber, Hand Pick	May-June, August-Sept.
Tissue	Tissue Contaminant Concentration	SOP 5.2	Surber, Hand Pick	May-June, August-Sept.
Fish				
Ecological	R, P/A	SOP 5.4	Seines, Minnow Traps, Electro-shocking	May-June
Tissue	Tissue Contaminant Concentration	SOP 5.4	Seines, Minnow Traps, Electro-shocking	May-June

C(s) = Cover by Species; C(t) = Total Cover; D = Density; P = Production by Species; P/A = Species Presence/Absence
RA = Relative Abundance; R = Richness

Table 9-9: Holding Times, Preservation Methods, and Sample Containers for Biota Samples

	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size++
SAMPLES FOR METALS ANALYSES				
Terrestrial Vegetation				
- Metals determined by ICP**	6 months	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Metals determined by GFAA+	6 months	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Hexavalent chromium	24 hours	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	25 g
- Mercury	28 days	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	5 g
Mammals, Birds, Benthic Macroinvertebrates, Fish				
- Metals determined by ICP	6 months	Freeze and ship with dry ice	Plastic	25 g
- Metals determined by GFAA	6 months	Freeze and ship with dry ice	Plastic	25 g
- Hexavalent chromium	24 hours	Freeze and ship with dry ice	Plastic	25 g
- Mercury	28 days	Freeze and ship with dry ice	Plastic	5 g

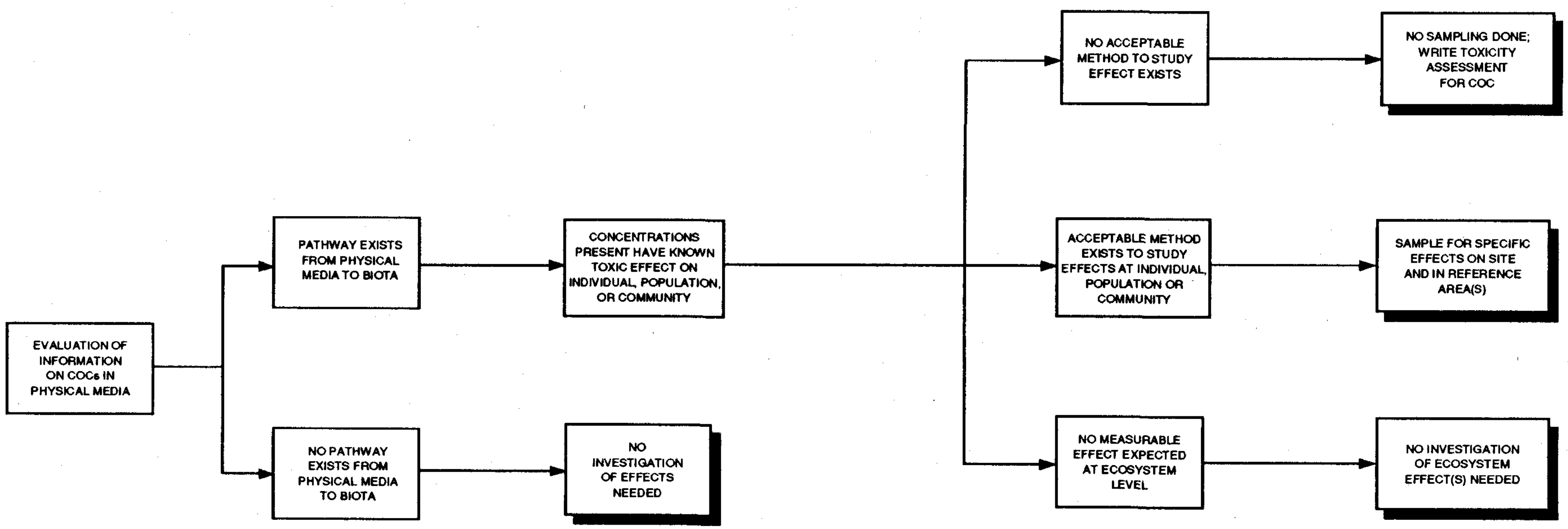
	Holding Time From Date Collected	Preservation Method	Container	Approximate Sample Size++
SAMPLES FOR RADIONUCLIDE ANALYSES				
<u>Terrestrial Vegetation</u>				
- Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 months	Freeze and ship with dry ice	Paper bag inserted into plastic bag and sealed	100 g
<u>Periphyton, Benthic Macroinvertebrates, Fish</u>				
- Uranium-233, 234, 235, 238 Americium-241 Plutonium-239/240	6 months	Freeze and ship with dry ice	Plastic	100 g

**ICP - Inductively Coupled Argon Plasma Emission Spectroscopy
+GFAA - Graphite Furnace Atomic Absorption Spectroscopy
++ - Sample size may vary with specific laboratory requirements

Figure 9-4. Spray Area 3, looking southwest from northeast corner.

Figure 9-2. Spray Area 1, looking southwest from SW082.

Figure 9-3. Spray Area 2, looking south from midpoint.

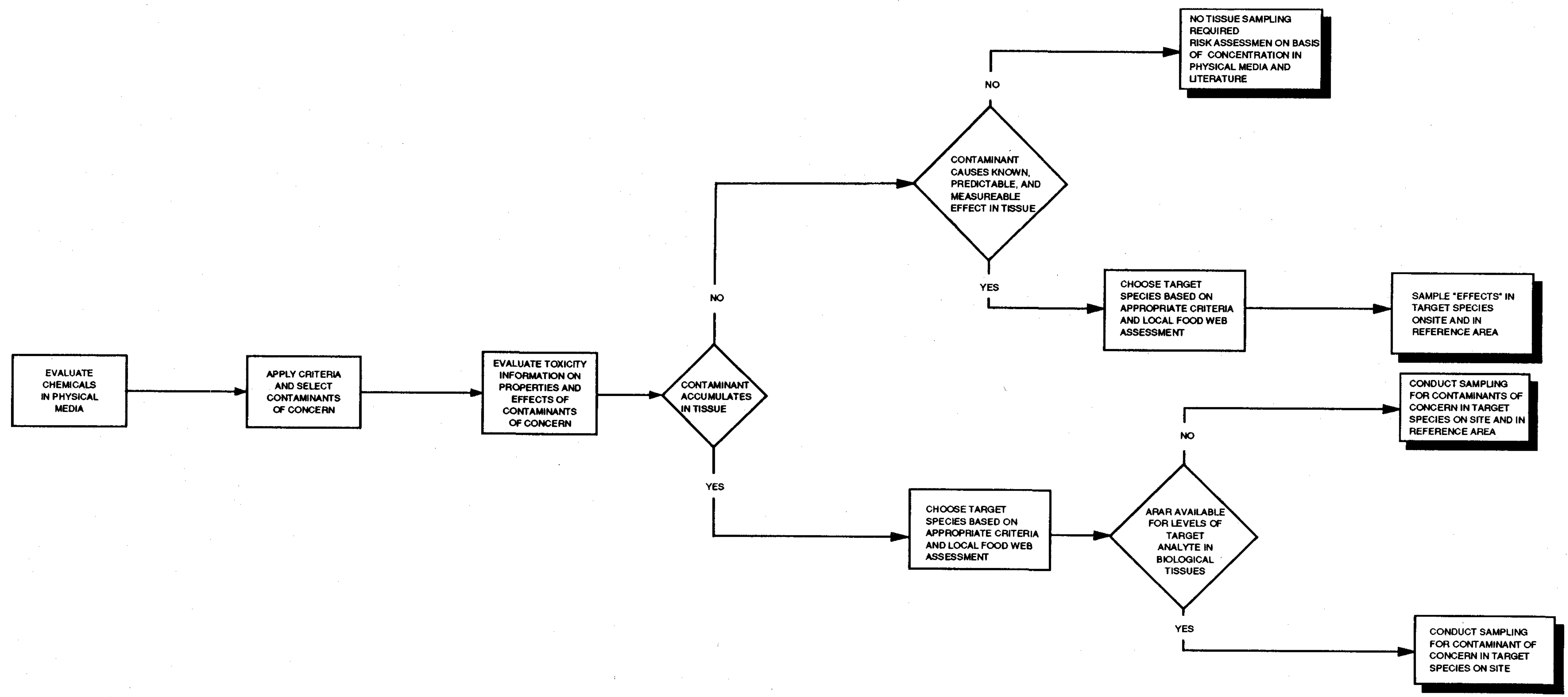


U.S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado

OPERABLE UNIT 11
PHASE I RFI/RI WORK PLAN

DECISION PROCESS FOR USE OF ECOLOGICAL ENDPOINTS AND REFERENCE AREAS

Figure 9-5 December 1991



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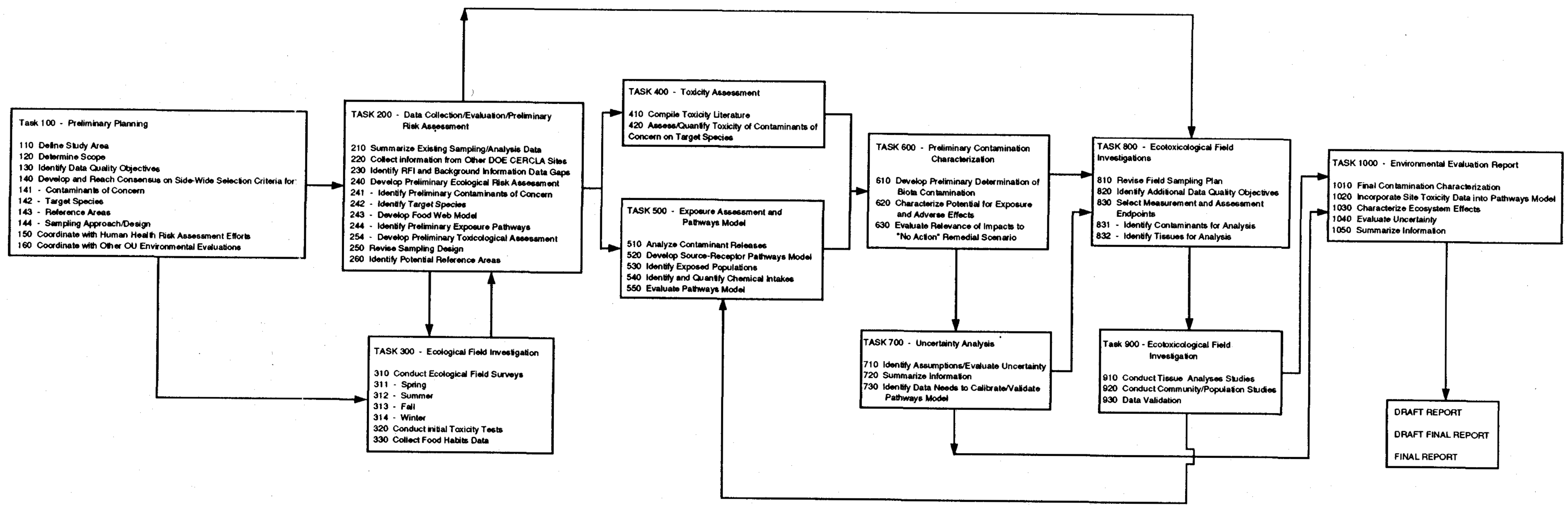
DECISION PROCESS FOR IDENTIFYING TARGET ANALYTES FOR TISSUE ANALYSIS

Figure 9-6 December 1991



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FLOW DIAGRAM:
INTERRELATIONSHIPS BETWEEN TASKS IN ENVIRONMENTAL EVALUATION

Figure 9-8 December 1991

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WEST SPRAY FIELD

ACTIVITY DESCRIPTION

TASK 100 - PRELIMINARY PLANNING

110 DEFINE STUDY AREA

120 DETERMINE SCOPE

130 IDENTIFY DATA QUALITY OBJECTIVES

150 COORDINATE WITH HUMAN HEALTH RISK ASSESSMENT EFFORTS

160 COORDINATE WITH OTHER OU ENVIRONMENTAL EVALUATIONS

TASK 200 - DATA COLLECTION/EVALUATION/PRELIMINARY RISK ASSESSMENT

210 SUMMARIZE EXISTING SAMPLING/ANALYSIS DATA

220 COLLECT INFORMATION FROM OTHER DOE CERCLA SITES

230 IDENTIFY RFI AND BACKGROUND INFORMATION DATA GAPS

240 DEVELOP PRELIMINARY ECOLOGICAL RISK ASSESSMENT

241 - IDENTIFY CONTAMINANTS OF CONCERN

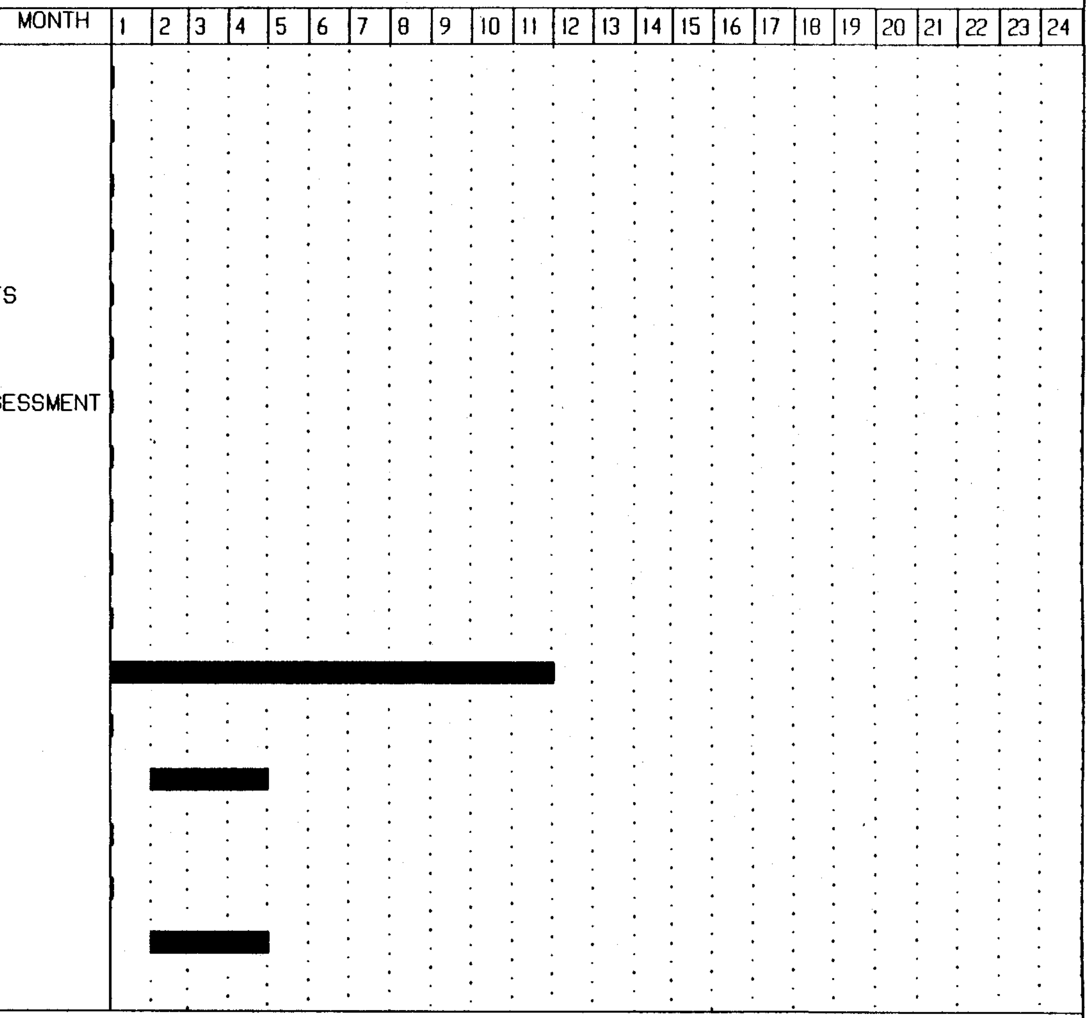
242 - IDENTIFY POTENTIAL TARGET SPECIES

243 - DEVELOP FOOD WEB MODEL

244 - IDENTIFY PRELIMINARY EXPOSURE PATHWAYS

245 - DEVELOP PRELIMINARY TOXICOLOGICAL ASSESSMENT

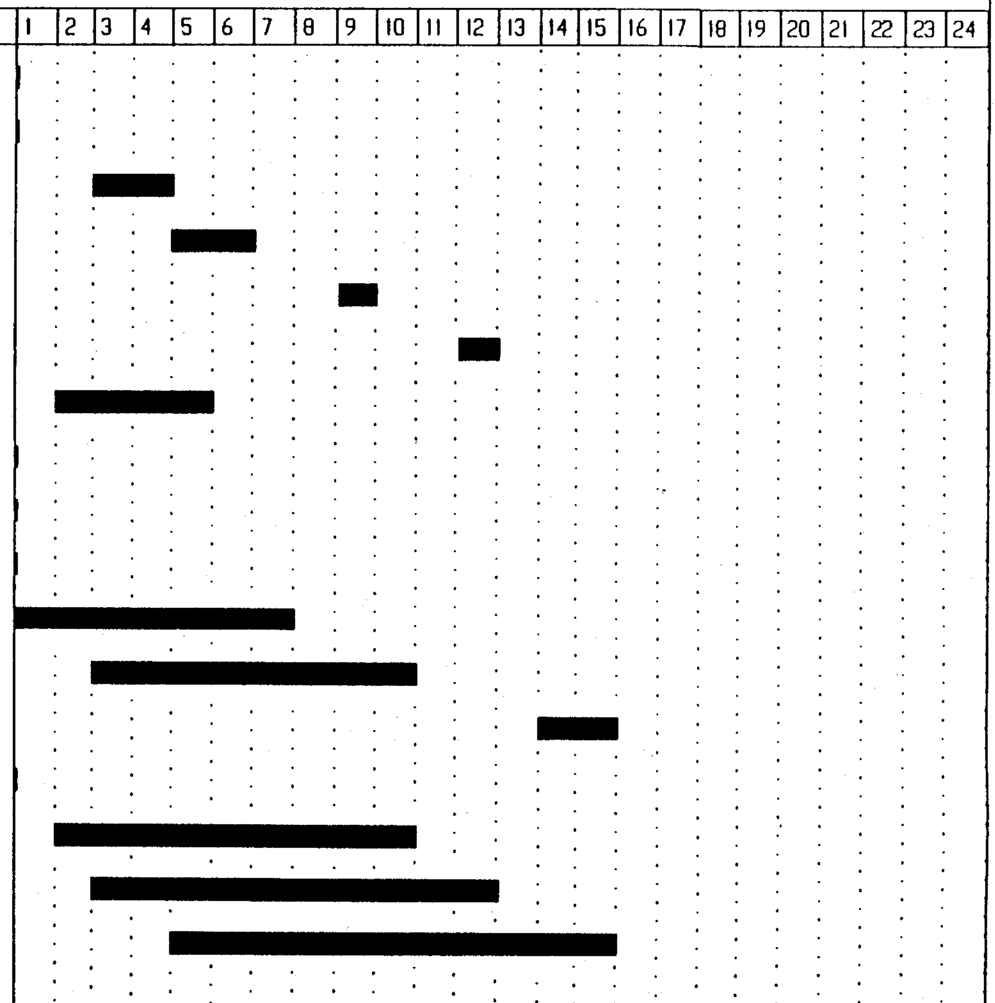
250 REVISE SAMPLING DESIGN



ENVIRONMENTAL EVALUATION
ACTIVITY SCHEDULE
FIGURE 9-9 DECEMBER 1991

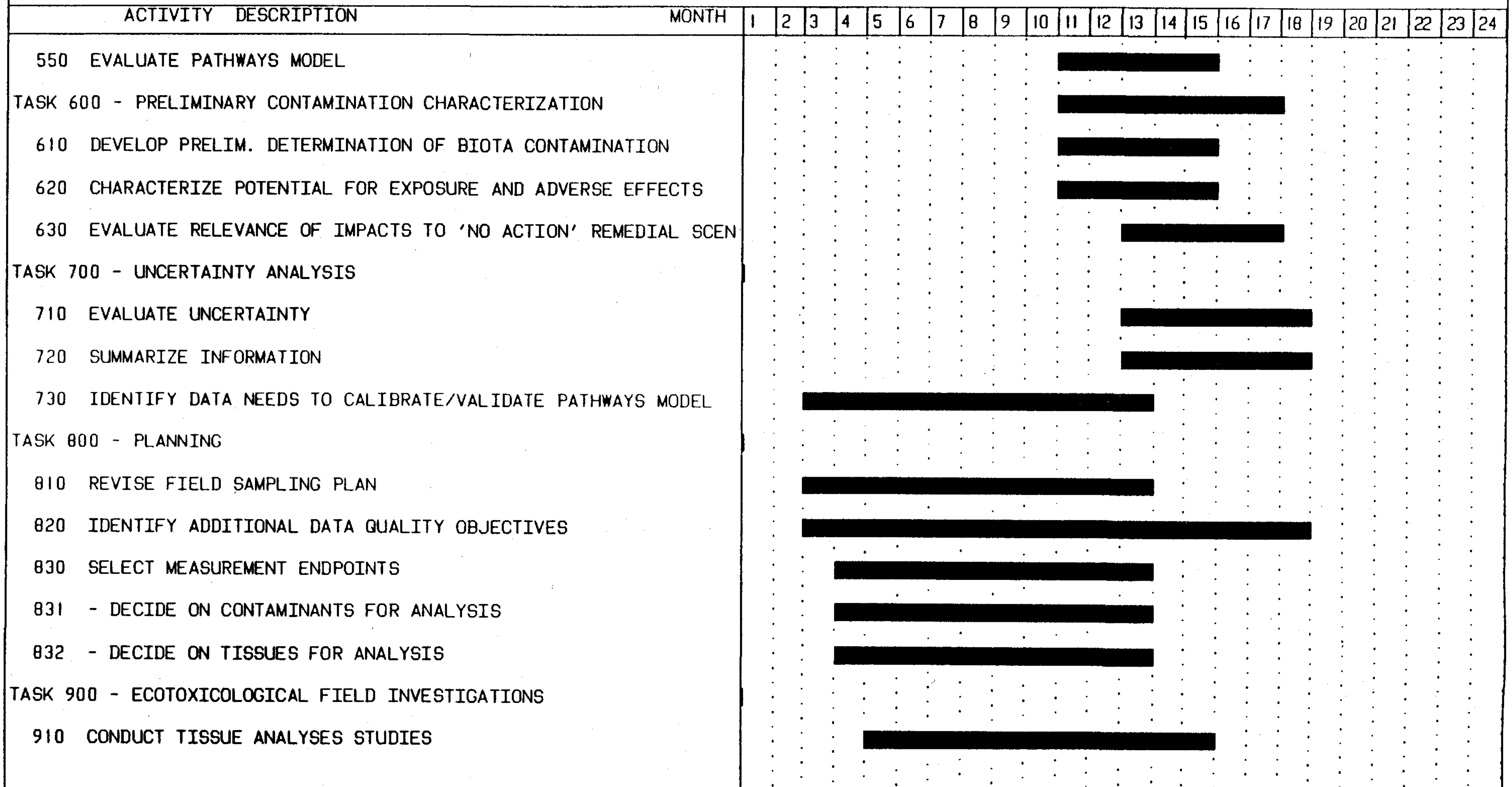
U. S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT II
PHASE I RFI/RI WORK PLAN
WEST SPRAY FIELD

ACTIVITY DESCRIPTION	MONTH 1–24
TASK 300 - ECOLOGICAL FIELD INVESTIGATION	
310 CONDUCT ECOLOGICAL FIELD SURVEYS	
311 - SPRING	
312 - SUMMER	
313 - FALL	
314 - WINTER	
320 CONDUCT INITIAL AQUATIC TOXICITY TESTS IF NECESSARY	
330 COLLECT FOOD HABITS DATA	
340 IDENTIFY POTENTIAL REFERENCE AREAS	
TASK 400 - TOXICITY ASSESSMENT	
410 COMPILE TOXICITY LITERATURE	
420 ASSESS/QUANTIFY TOXICITY OF COC's ON TARGET SPECIES	
TASK 500 - EXPOSURE ASSESSMENT AND PATHWAYS MODEL	
510 ANALYZE CONTAMINANT RELEASES	
520 DEVELOP SOURCE-TARGET PATHWAYS MODEL	
530 IDENTIFY EXPOSED POPULATIONS	
540 IDENTIFY AND QUANTIFY CHEMICAL INTAKES	



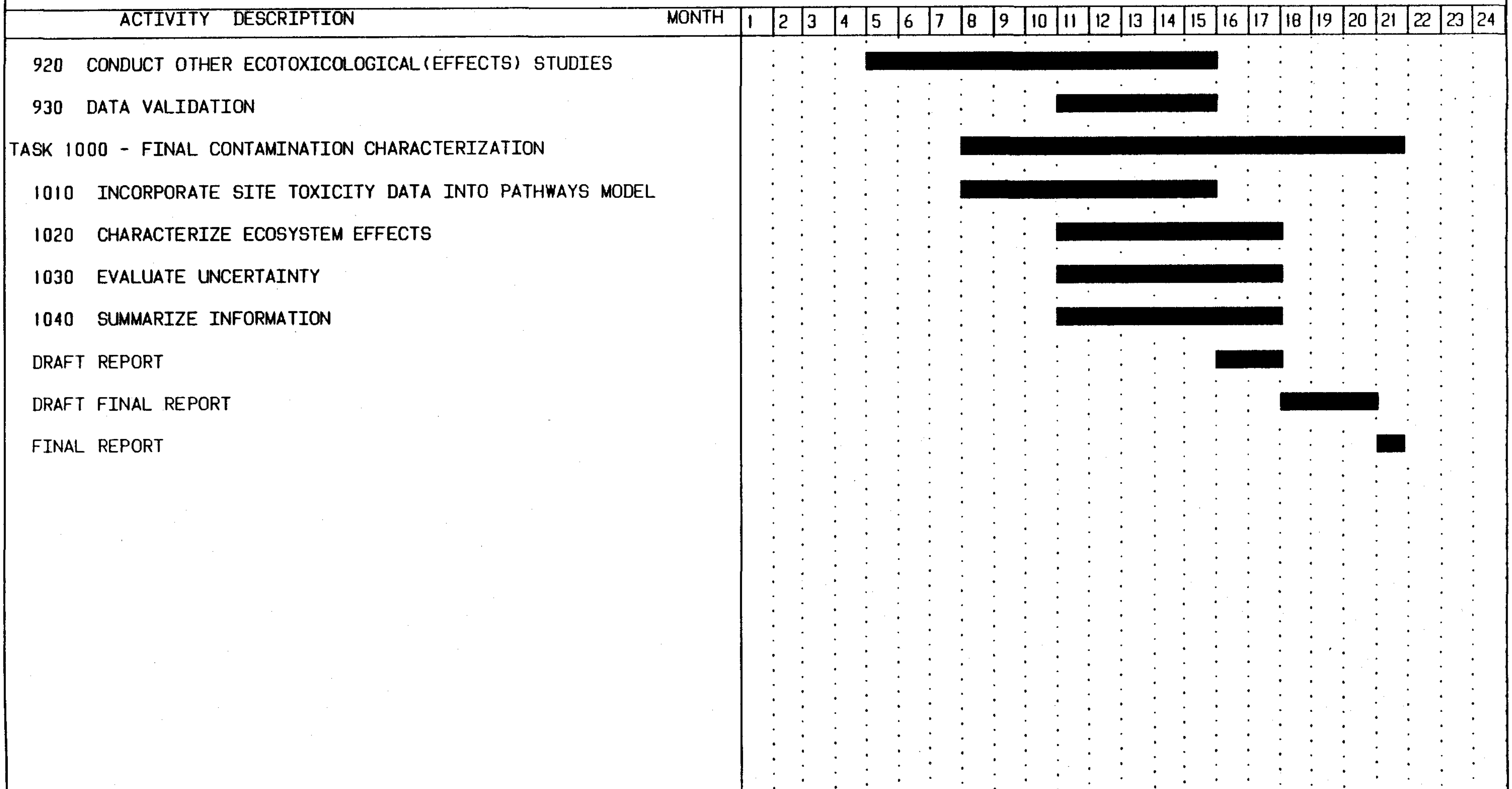
ENVIRONMENTAL EVALUATION
ACTIVITY SCHEDULE
FIGURE 9-9 DECEMBER 1991

U. S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT 11
PHASE I RFI/RI WORK PLAN
WEST SPRAY FIELD



ENVIRONMENTAL EVALUATION
ACTIVITY SCHEDULE
FIGURE 9-9 DECEMBER 1991

U. S. DEPARTMENT OF ENERGY
Rocky Flats Plant, Golden, Colorado
OPERABLE UNIT II
PHASE I RFI/RI WORK PLAN
WEST SPRAY FIELD



ENVIRONMENTAL EVALUATION
ACTIVITY SCHEDULE
FIGURE 9-9 DECEMBER 1991

10.0 . QUALITY ASSURANCE ADDENDUM

A site specific Quality Assurance Addendum will be provided.

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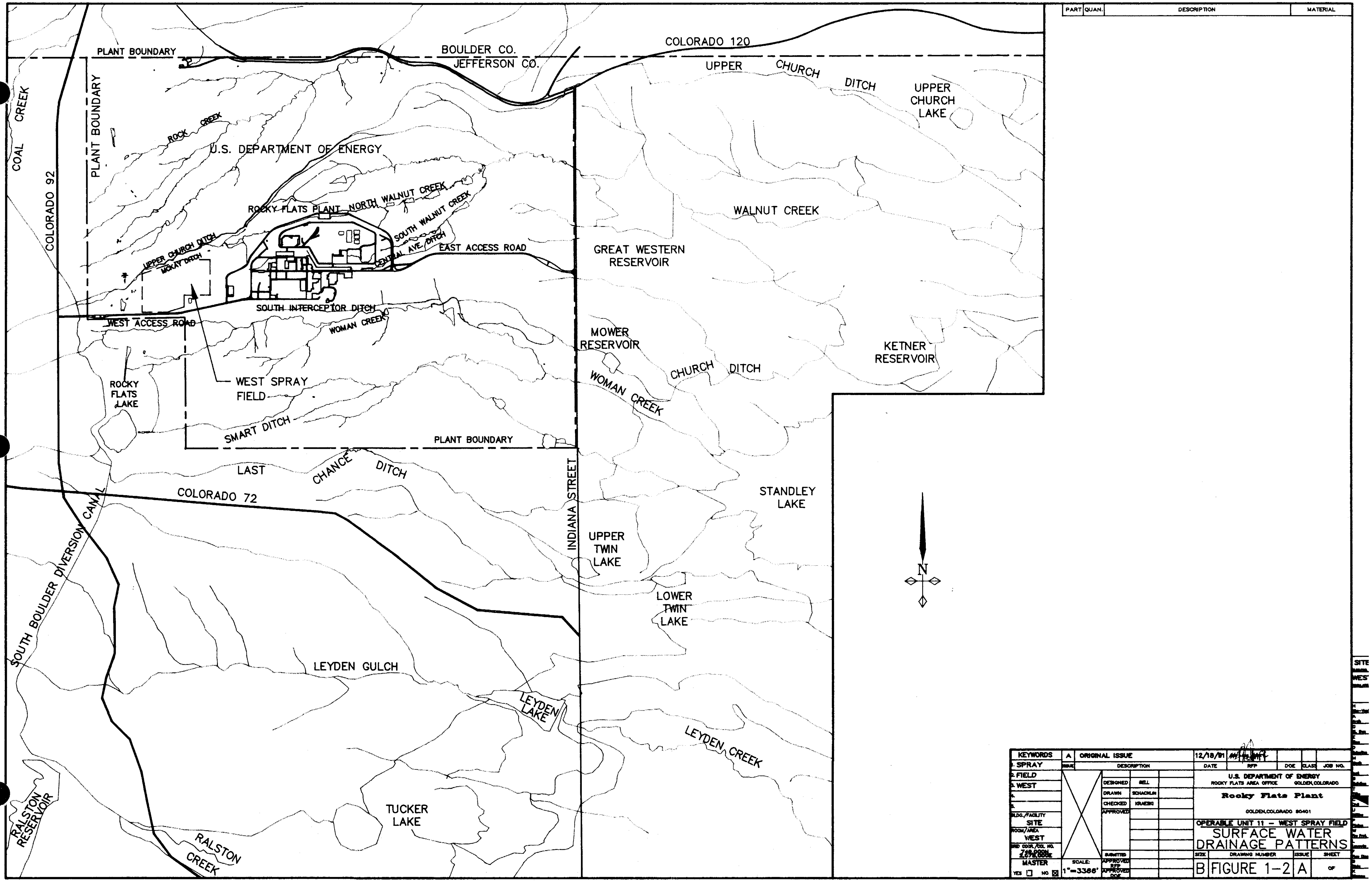
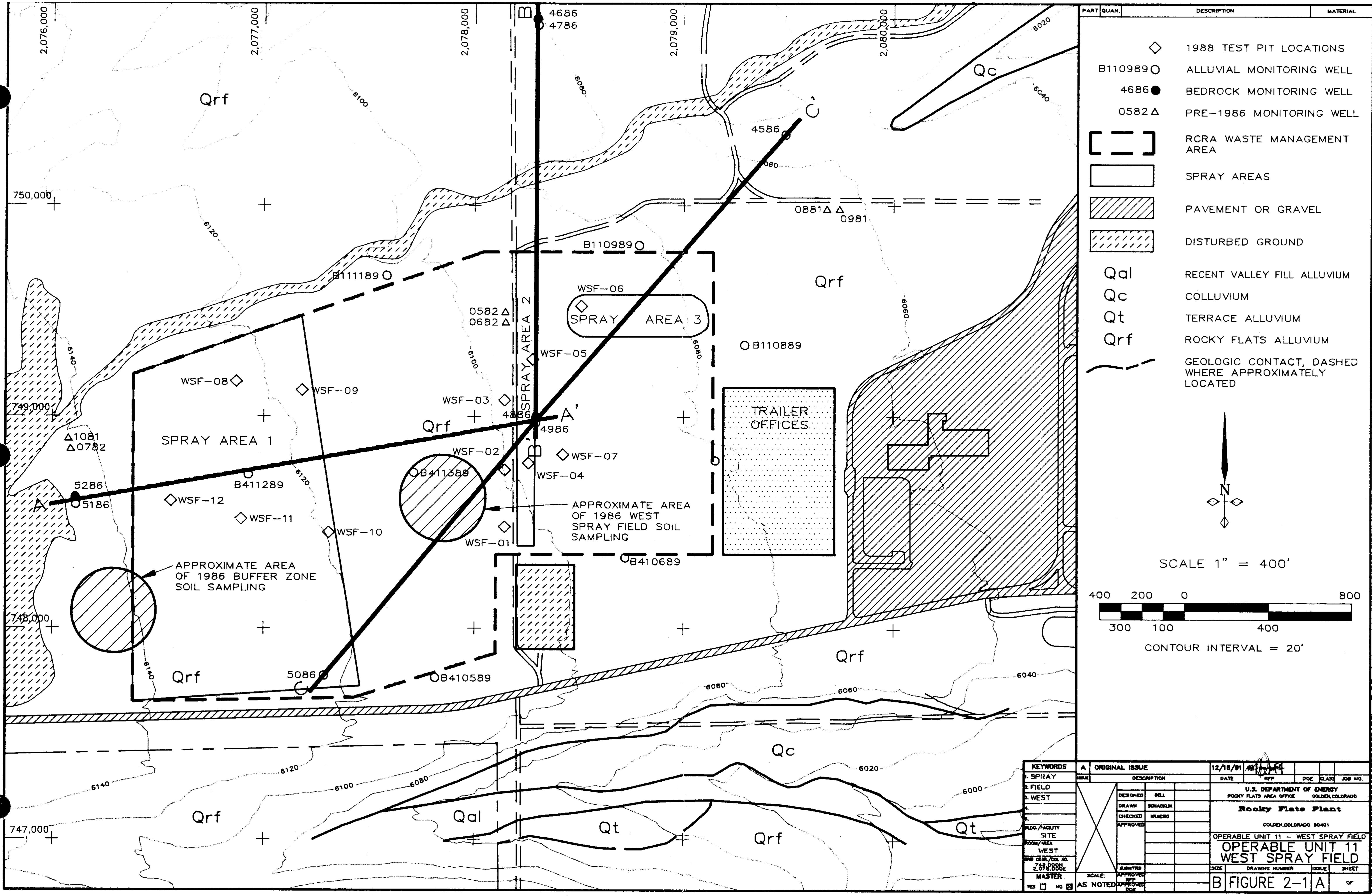


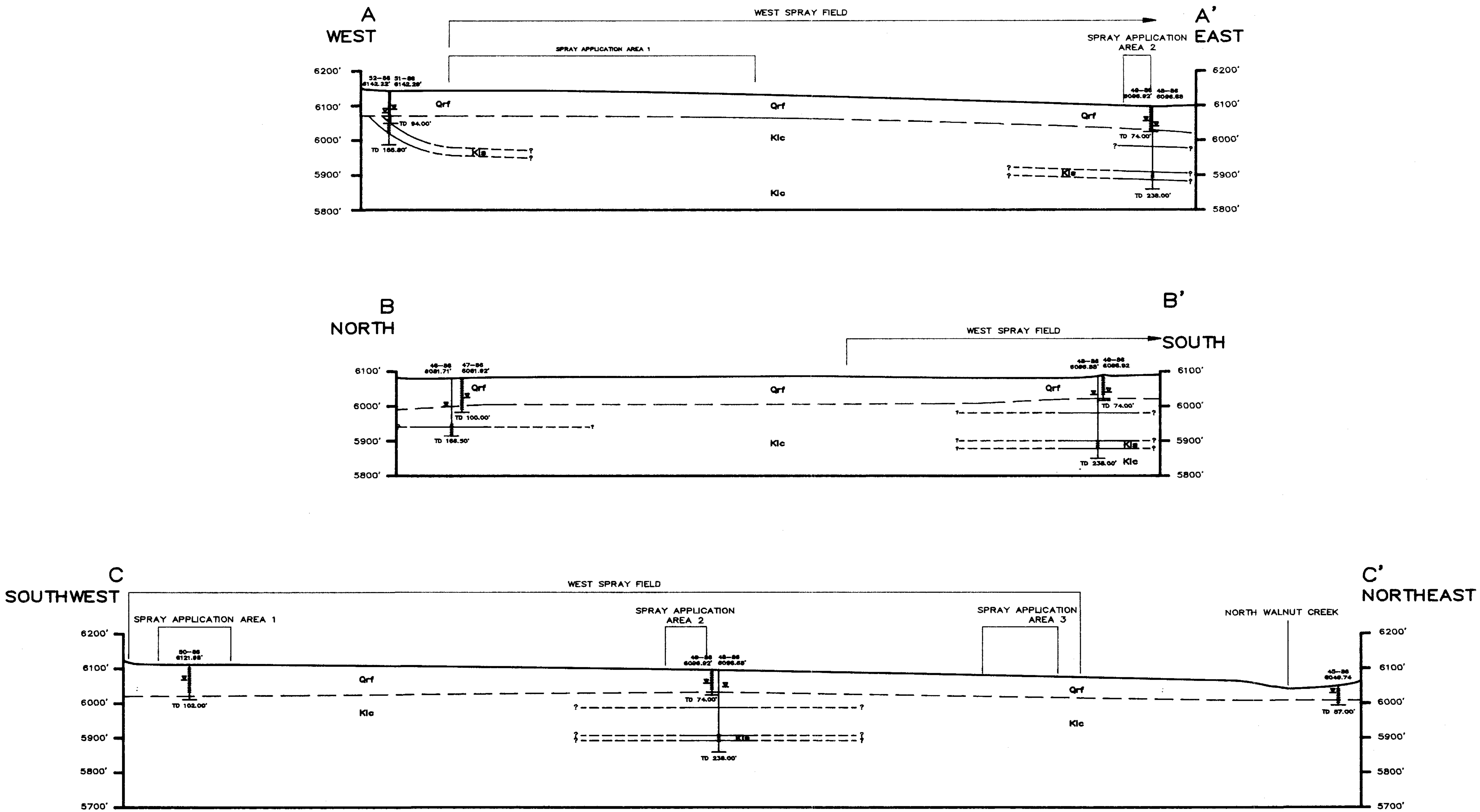
"COMPUTER-GENERATED; NO MANUAL CHANGES ALLOWED"



KEYWORDS	A	ORIGINAL ISSUE	12/18/91
1. SPRAY	ISSUE	DESCRIPTION	DATE
2. FIELD	DESIGNED	BELL	U.S. DEPARTMENT OF ENERGY, ROCKY FLATS AREA OFFICE, GOLDEN, COLORADO
3. WEST	DRAWN	SCHACKLIN	Rocky Flats Plant
	CHECKED	KRAESIG	GOLDEN, COLORADO 80401
BLDG./FACILITY: SITE	APPROVED		OPERABLE UNIT 11 – WEST SPRAY FIELD
ROOM/AREA: WEST			OPERABLE UNIT 11 WEST SPRAY FIELD
GRID COOR./COL. NO.: 748,000N 2,078,000E	SCALE: AS NOTED		SIZE: B DRAWING NUMBER: FIGURE 2-1 ISSUE: A
MASTER YES ☐ NO ☒			

"COMPUTER-GENERATED; NO MANUAL CHANGES ALLOWED"

PART	QUAN.	DESCRIPTION	MATERIAL



EXPLANATION

SCALE:
NO VERTICAL EXAGGERATION

300 200 100 0 300 600

WELL IDENTIFICATION
GROUND SURFACE ELEVATION (SURVEYED)

WATER LEVEL (MEASURED 04/01/88)

GEOLOGIC CONTACT (DASHED WHERE INFERRED)

SCREENED INTERVAL

TOTAL DEPTH DRILLED

NOTE: 1986 WELL LOCATIONS RESURVEYED DURING 1988.
THIS PLATE REFLECTS NEW LOCATIONS AND ELEVATIONS.

QUATERNARY

- Qc COLLUVIUM
- Qd DISTURBED GROUND
- Qrf ROCKY FLATS ALLUVIUM
- Qvf VALLEY FILL ALLUVIUM

CRETACEOUS

- Klc LARAMIE FORMATION (CLAYSTONE)
- Kls LARAMIE FORMATION (SANDSTONE)

KEYWORDS: 1. SPRAY 2. FIELD 3. WEST

BLDG./FACILITY: SITE
ROOM/AREA: WEST

MASTER: YES ☐ NO ☒

A ORIGINAL ISSUE 12/18/91

DESIGNED: GARD
DRAWN: SCHACKLIN
CHECKED: KRAESKI
APPROVED

SCALE: GRAPHIC

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant

GOLDEN, COLORADO 80401

OPERABLE UNIT 11 – WEST SPRAY FIELD

GEOLOGIC CROSS SECTIONS

SIZE: B DRAWING NUMBER: FIGURE 2-2 ISSUE: A SHEET: OF

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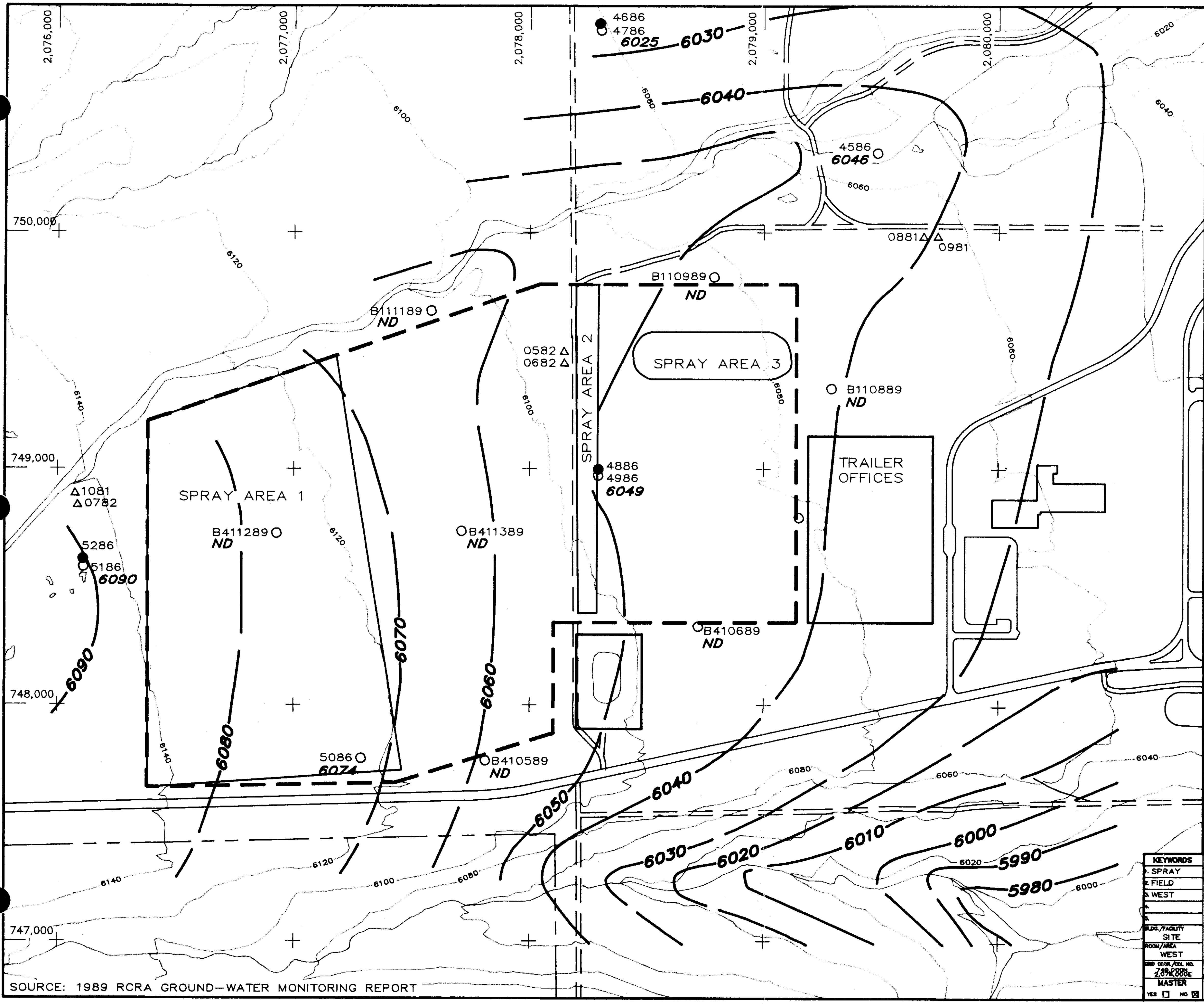


PART	QUAN.	DESCRIPTION	MATERIAL

B110989 ○ ALLUVIAL MONITORING WELL

4686 ● BEDROCK MONITORING WELL

0582 △ PRE-1986 MONITORING WELL

RCRA WASTE MANAGEMENT AREA

SPRAY AREAS

6025 POTENTIOMETRIC SURFACE ELEVATION MAY 1989 (FEET ABOVE MEAN SEA LEVEL)

6040 LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL) DASHED WHERE APPROXIMATELY LOCATED CONTOUR INTERVAL–10 FEET

ND NO DATA – WELL NOT YET COMPLETED

N

SCALE 1" = 400'

400 200 0 800

300 100 400

CONTOUR INTERVAL = 20'

KEYWORDS	
1. SPRAY	
2. FIELD	
3. WEST	
BLDG./FACILITY	SITE
ROOM/AREA	WEST
GRID COOR./COL. NO.	748,000N 2,078,000E
MASTER	YES ☐ NO ☒

A	ORIGINAL ISSUE	12/18/91		
ISSUE	DESCRIPTION	DATE	RFP	DOE
DESIGNED	GARD			
DRAWN	SCHACKLIN			
CHECKED	KRAEBEI			
APPROVED				
SCALE: AS NOTED	SUBMITTED / APPROVED RFP / APPROVED DOE			

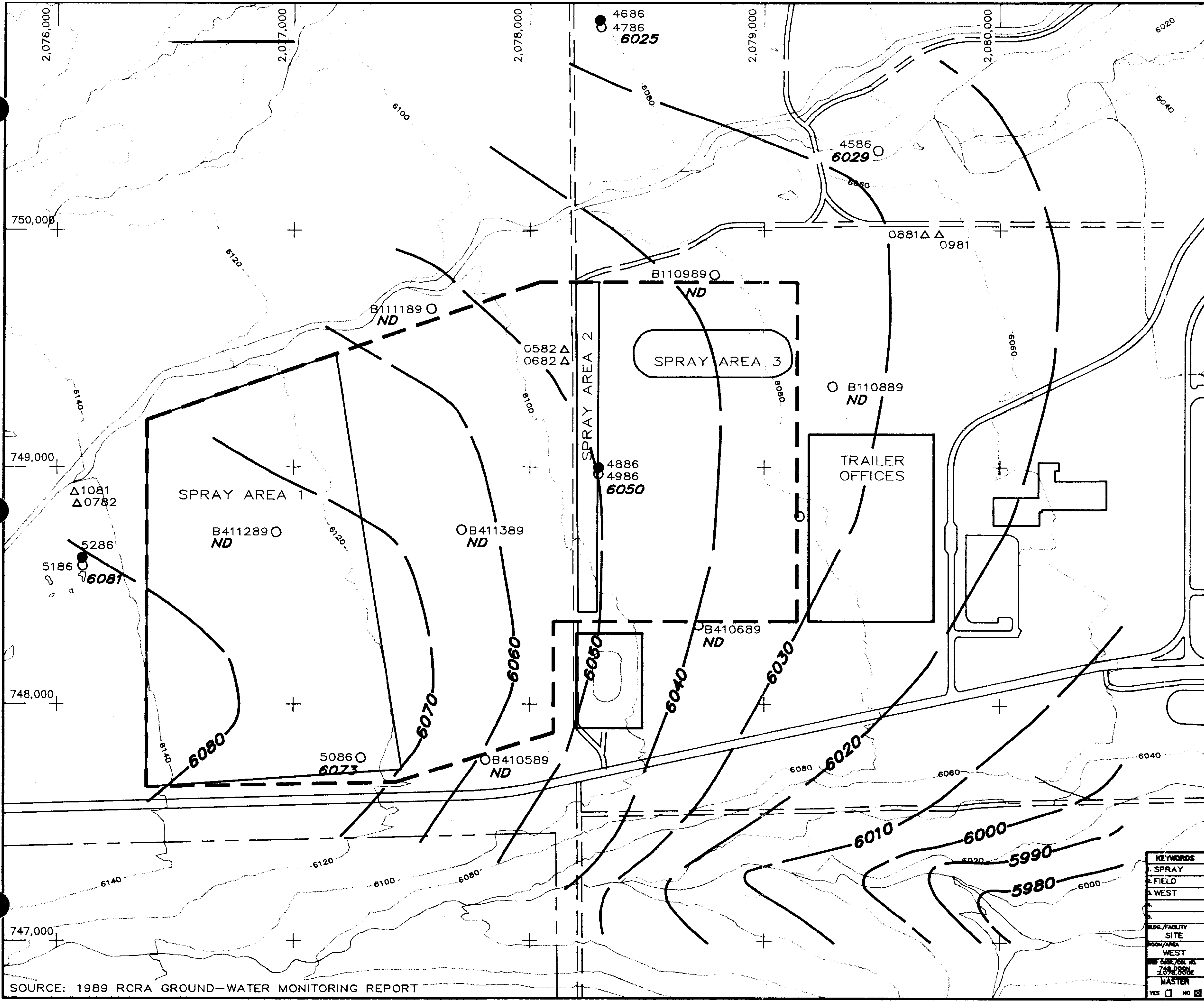
U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant
GOLDEN, COLORADO 80401

OPERABLE UNIT 11– WEST SPRAY FIELD
POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS SECOND QUARTER 1989

SIZE	DRAWING NUMBER	ISSUE	SHEET
B	FIGURE 2–3	A	OF

"COMPUTER–GENERATED: NO MANUAL CHANGES ALLOWED"



PART	QUAN.	DESCRIPTION	MATERIAL

- B110989 ○ ALLUVIAL MONITORING WELL
- 4686 ● BEDROCK MONITORING WELL
- 0582 △ PRE-1986 MONITORING WELL
- RCRA WASTE MANAGEMENT AREA
- SPRAY AREAS
- 6025 POTENTIOMETRIC SURFACE ELEVATION AUGUST 1989 (FEET ABOVE MEAN SEA LEVEL)
- 6040 LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL) DASHED WHERE APPROXIMATELY LOCATED CONTOUR INTERVAL–10 FEET
- ND NO DATA – WELL NOT YET COMPLETED

N

SCALE 1" = 400'

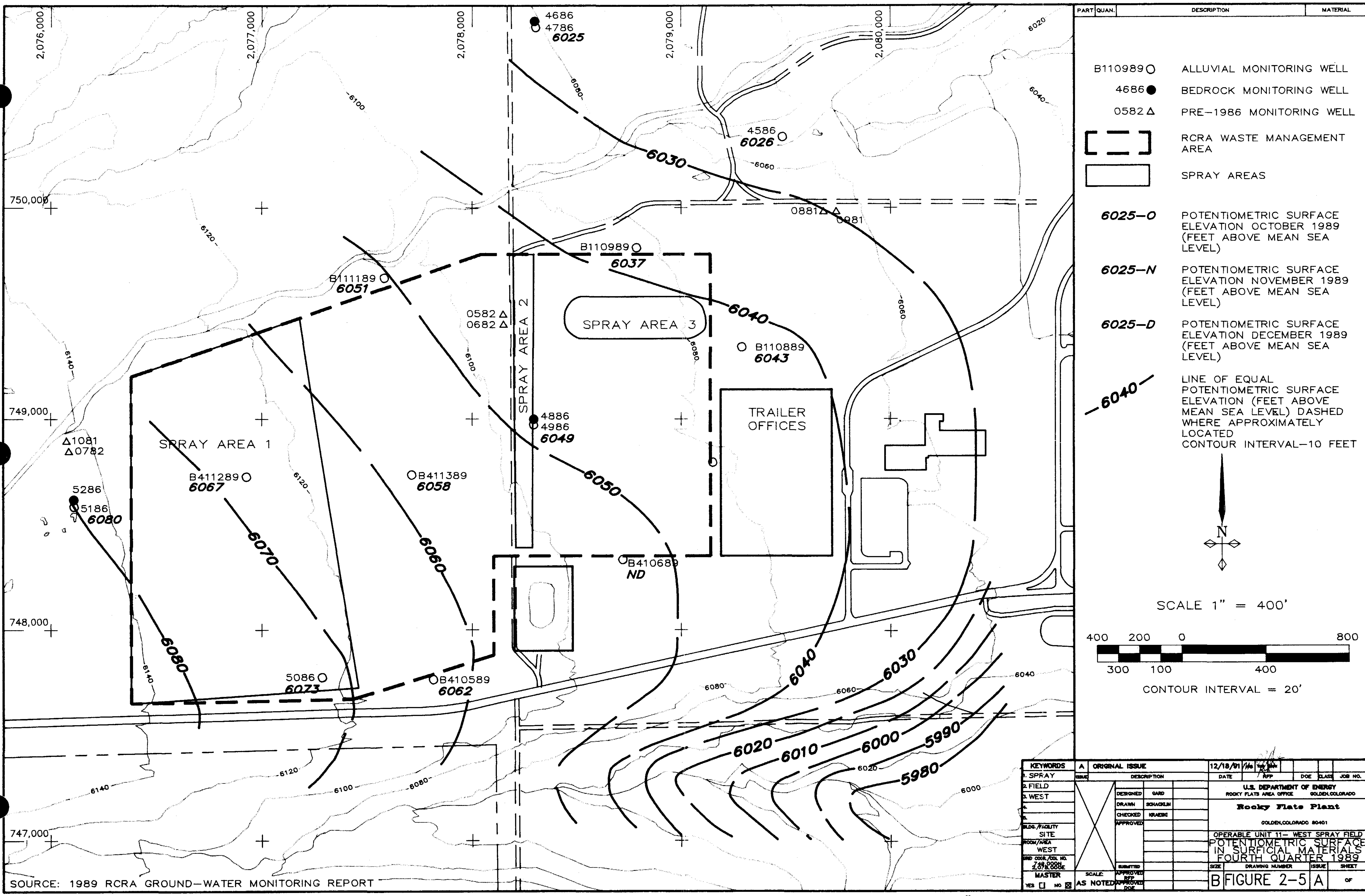
400 200 0 800
300 100 400

CONTOUR INTERVAL = 20'

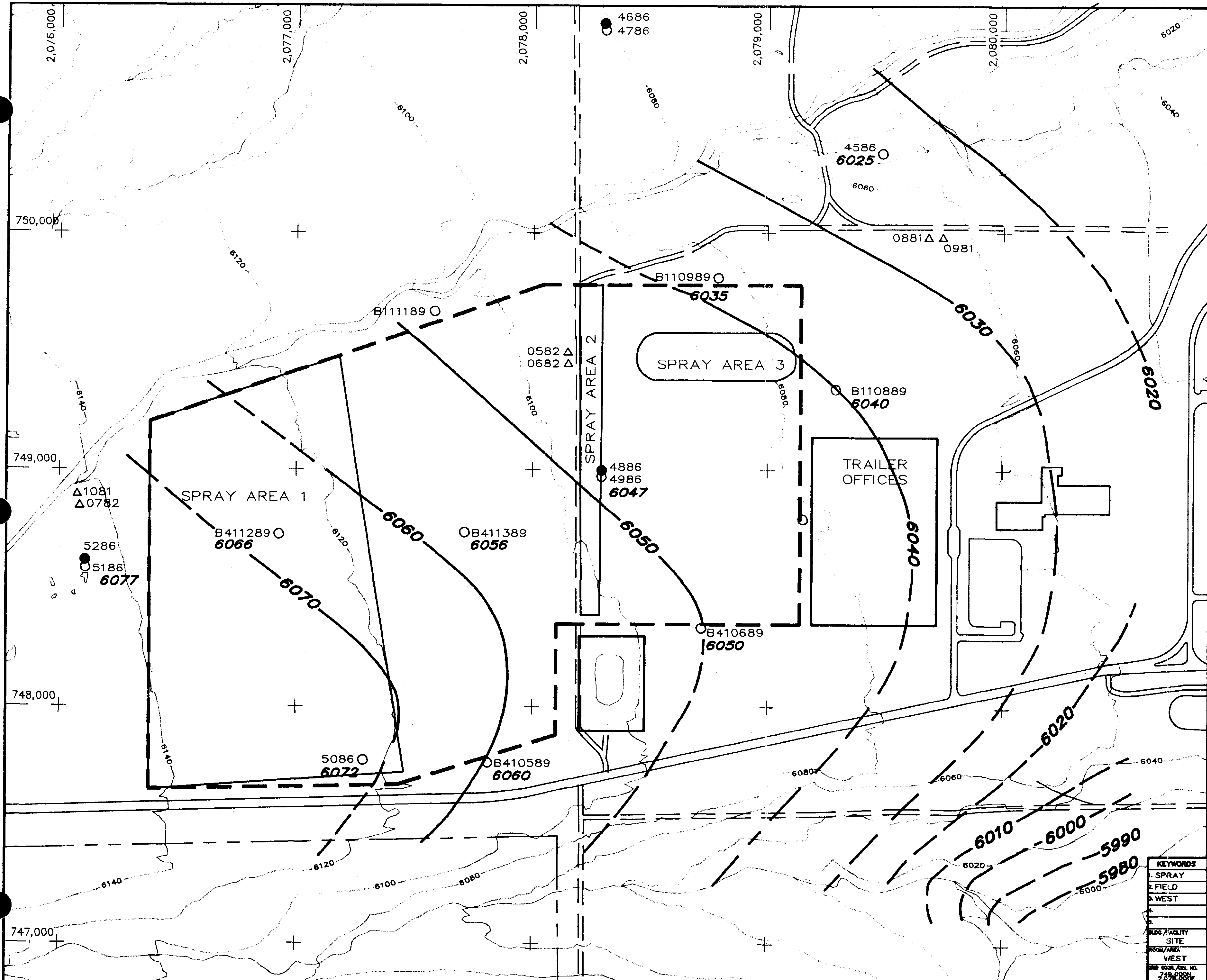
KEYWORDS	A	ORIGINAL ISSUE	12/18/91
1. SPRAY	ISSUE	DESCRIPTION	DATE / RFP / DOE / CLASS / JOB NO.
2. FIELD	DESIGNED GARD		U.S. DEPARTMENT OF ENERGY ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
3. WEST	DRAWN SCHACHLIN		Rocky Flats Plant GOLDEN, COLORADO 80401
BLDG./FACILITY SITE	CHECKED KRAEBS		OPERABLE UNIT 11– WEST SPRAY FIELD POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS THIRD QUARTER 1989
ROOM/AREA WEST	APPROVED		
GRID COOR./COL. NO. 748,000N 2,078,000E	SUBMITTED / APPROVED RFP / APPROVED DOE		SIZE B / DRAWING NUMBER FIGURE 2-4 / ISSUE A / SHEET OF
MASTER YES ☐ NO ☒	SCALE: AS NOTED		

SITE
WEST

"COMPUTER–GENERATED; NO MANUAL CHANGES ALLOWED"



"COMPUTER-GENERATED; NO MANUAL CHANGES ALLOWED"



SOURCE: 1990 RCRA GROUND-WATER MONITORING REPORT

PART	QUAN.	DESCRIPTION	MATERIAL

B110989○ ALLUVIAL MONITORING WELL

4686● BEDROCK MONITORING WELL

0582△ PRE-1986 MONITORING WELL

RCRA WASTE MANAGEMENT AREA

SPRAY AREAS

6025 POTENTIOMETRIC SURFACE ELEVATION 1990 (FEET ABOVE MEAN SEA LEVEL)

6040 LINE OF EQUAL POTENTIOMETRIC SURFACE ELEVATION (FEET ABOVE MEAN SEA LEVEL) DASHED WHERE APPROXIMATELY LOCATED CONTOUR INTERVAL–10 FEET

ND NO DATA – WELL NOT YET COMPLETED

N

SCALE 1" = 400'

400 200 0 800
300 100 400

CONTOUR INTERVAL = 20'

KEYWORDS: SPRAY, FIELD, WEST
BLDG./FACILITY: SITE
ROOM/AREA: WEST
GRID COOR./COL. NO.: 748,000N, 2,078,000E
MASTER: YES ☐ NO ☒

A ORIGINAL ISSUE 12/18/91

DESIGNED: GARD
DRAWN: SCHACKLIN
CHECKED: KRAEGI

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant

GOLDEN, COLORADO 80401

OPERABLE UNIT 11– WEST SPRAY FIELD
POTENTIOMETRIC SURFACE IN SURFICIAL MATERIALS FIRST QUARTER 1990

SIZE: B | DRAWING NUMBER: FIGURE 2-6 | ISSUE: A | SCALE: AS NOTED

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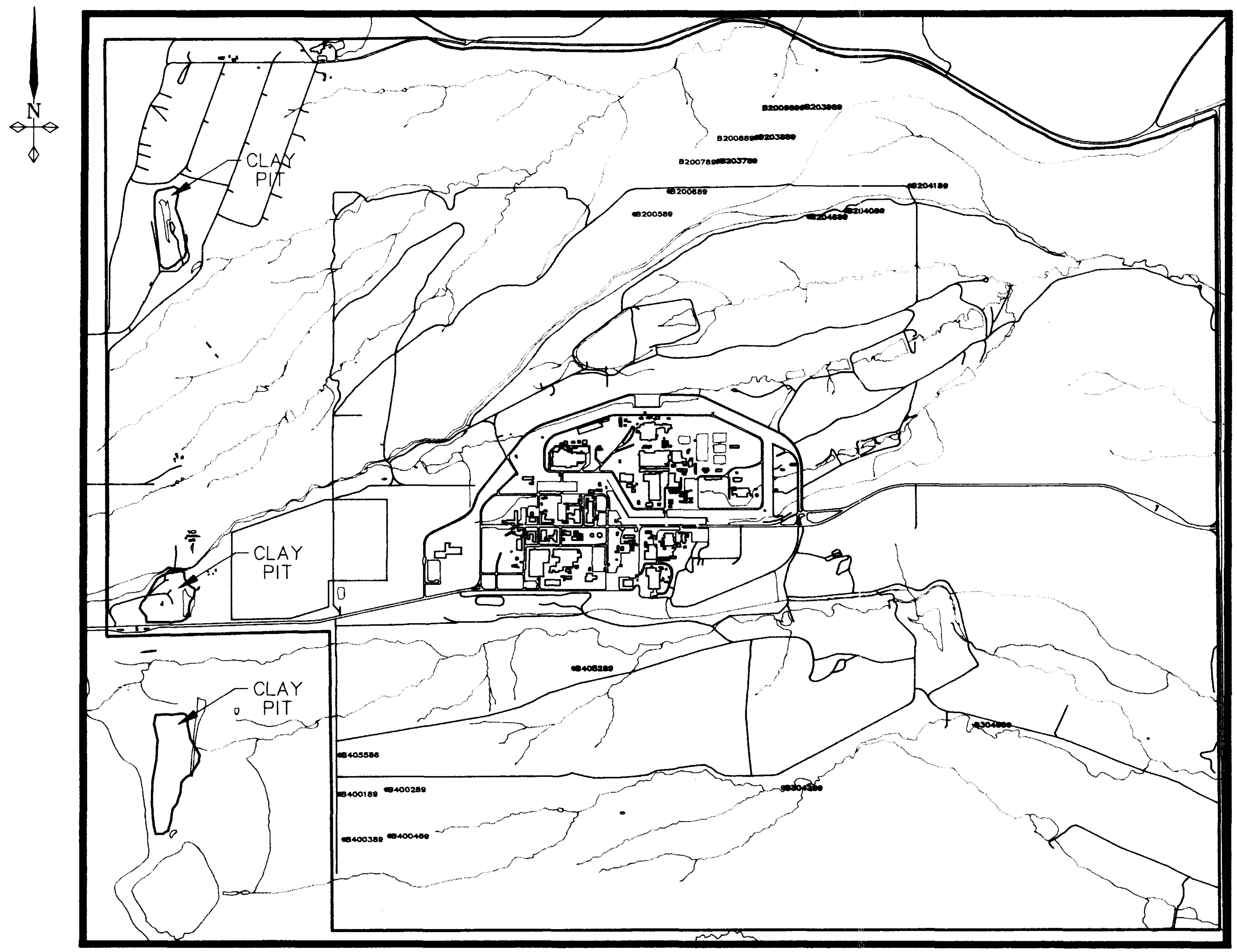


PART	QUAN.	DESCRIPTION	MATERIAL

KEYWORDS
1. SPRAY
2. FIELD
3. WEST

BLDG./FACILITY SITE
ROOM/AREA WEST
GRID COOR./COL. NO. 748,000N 2,078,000E
MASTER YES ☐ NO ☒

A ORIGINAL ISSUE 12/18/91

ISSUE | DESCRIPTION | DATE | RFP | DOE | CLASS | JOB NO.

DESIGNED BELL
DRAWN SCHACKLIN
CHECKED KRAEBS
APPROVED

SCALE: 1"=2000'
SUBMITTED
APPROVED RFP
APPROVED DOE

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

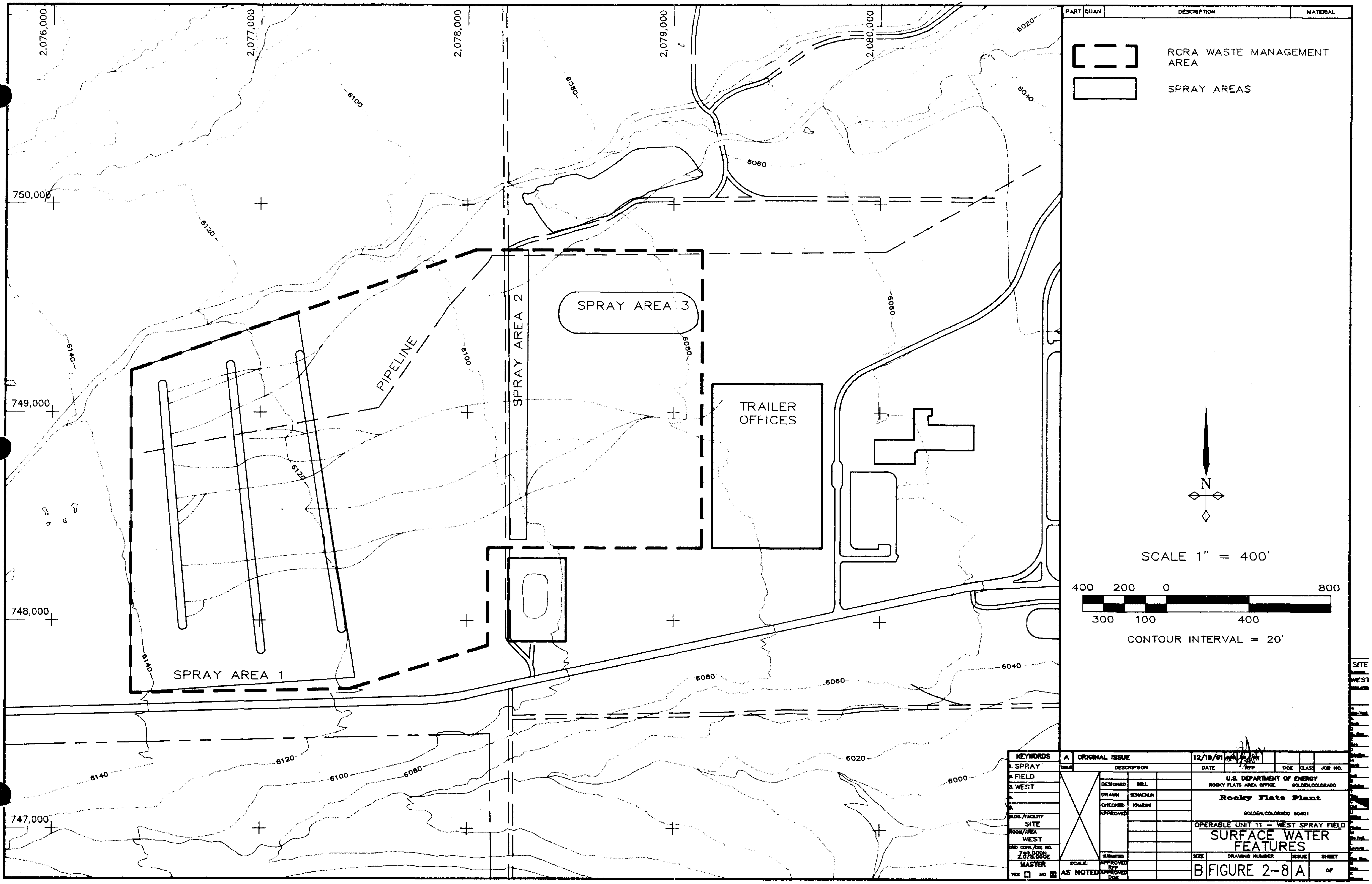
Rocky Flats Plant

GOLDEN, COLORADO 80401

OPERABLE UNIT 11 – WEST SPRAY FIELD
BACKGROUND SOIL AND GROUNDWATER SAMPLING LOCATIONS

SIZE B | DRAWING NUMBER FIGURE 2-7 | ISSUE A | SHEET OF

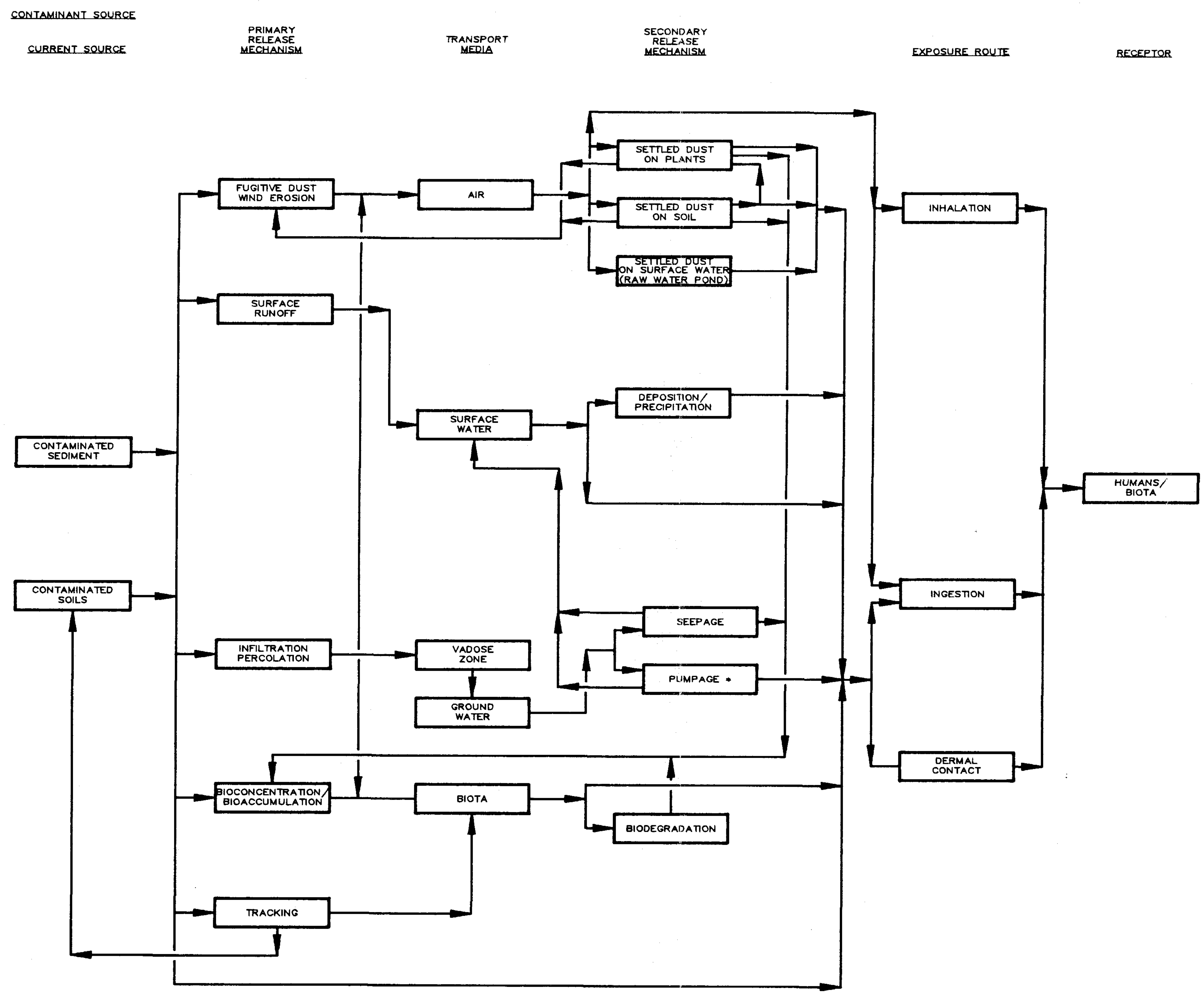
"COMPUTER–GENERATED; NO MANUAL CHANGES ALLOWED"



"COMPUTER-GENERATED; NO MANUAL CHANGES ALLOWED"

PART	QUAN.	DESCRIPTION	MATERIAL

* DEGIGNATES A POTENTIAL FUTURE USE RELEASE MECHANISM.



KEYWORDS: 1. SPRAY 2. FIELD 3. WEST

BLDG./FACILITY: SITE
ROOM/AREA: WEST
GRID COOR./COL NO.: 749,000N 2,078,000E
MASTER: YES ☐ NO ☒

SCALE: AS NOTED

ISSUE	DESCRIPTION	DATE	RFP	DOE
A	ORIGINAL ISSUE	12/18/91		

DESIGNED: BIERBAUM
DRAWN: SCHACKLIN
CHECKED: KRAEBD
APPROVED
SUBMITTED
APPROVED RFP
APPROVED DOE

U.S. DEPARTMENT OF ENERGY
ROCKY FLATS AREA OFFICE GOLDEN, COLORADO

Rocky Flats Plant
GOLDEN, COLORADO 80401

OPERABLE UNIT 11 – WEST SPRAY FIELD

SITE CONCEPTUAL MODEL

SIZE: D DRAWING NUMBER: FIGURE 2-10 ISSUE: A SHEET: OF

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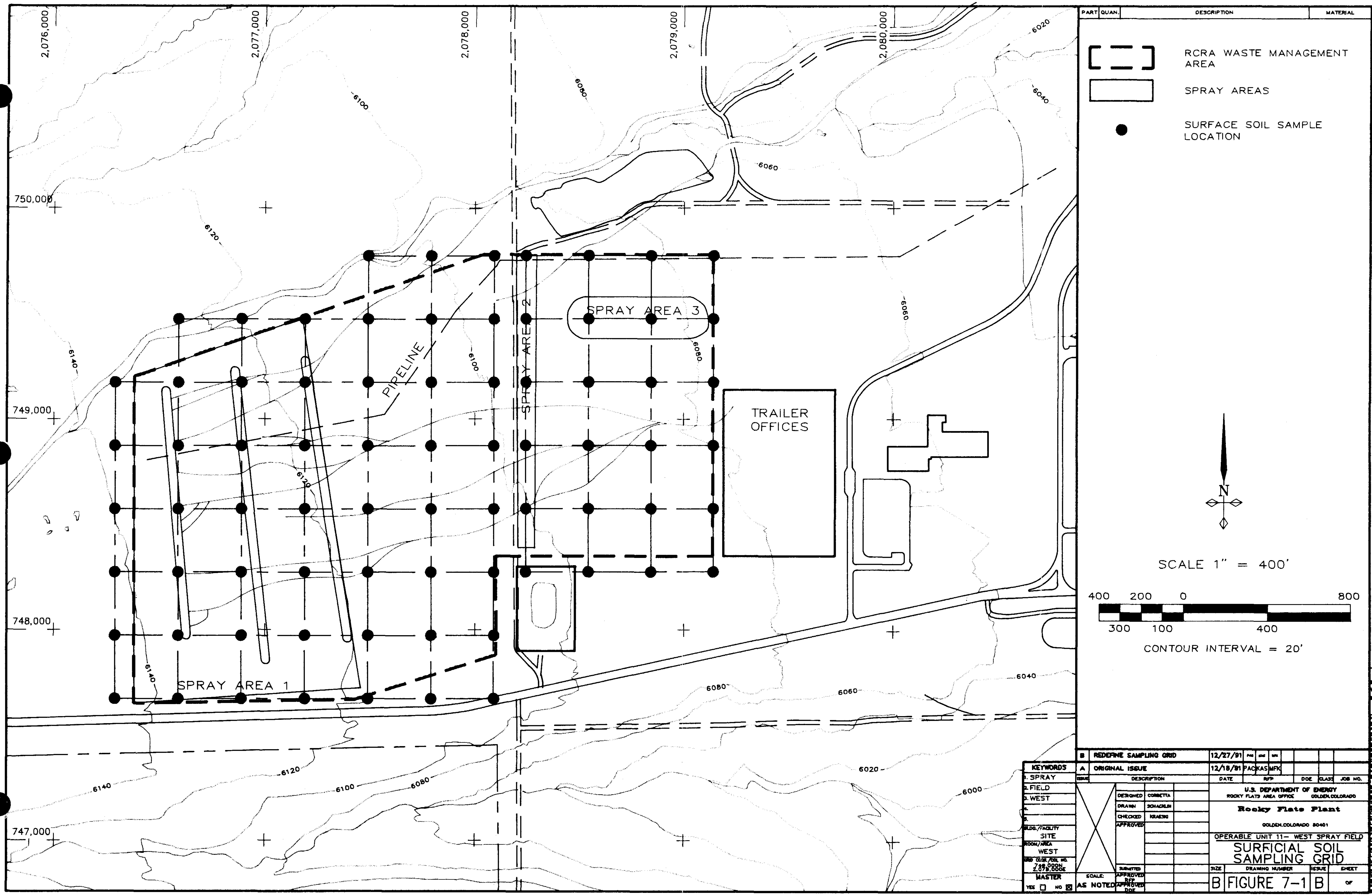

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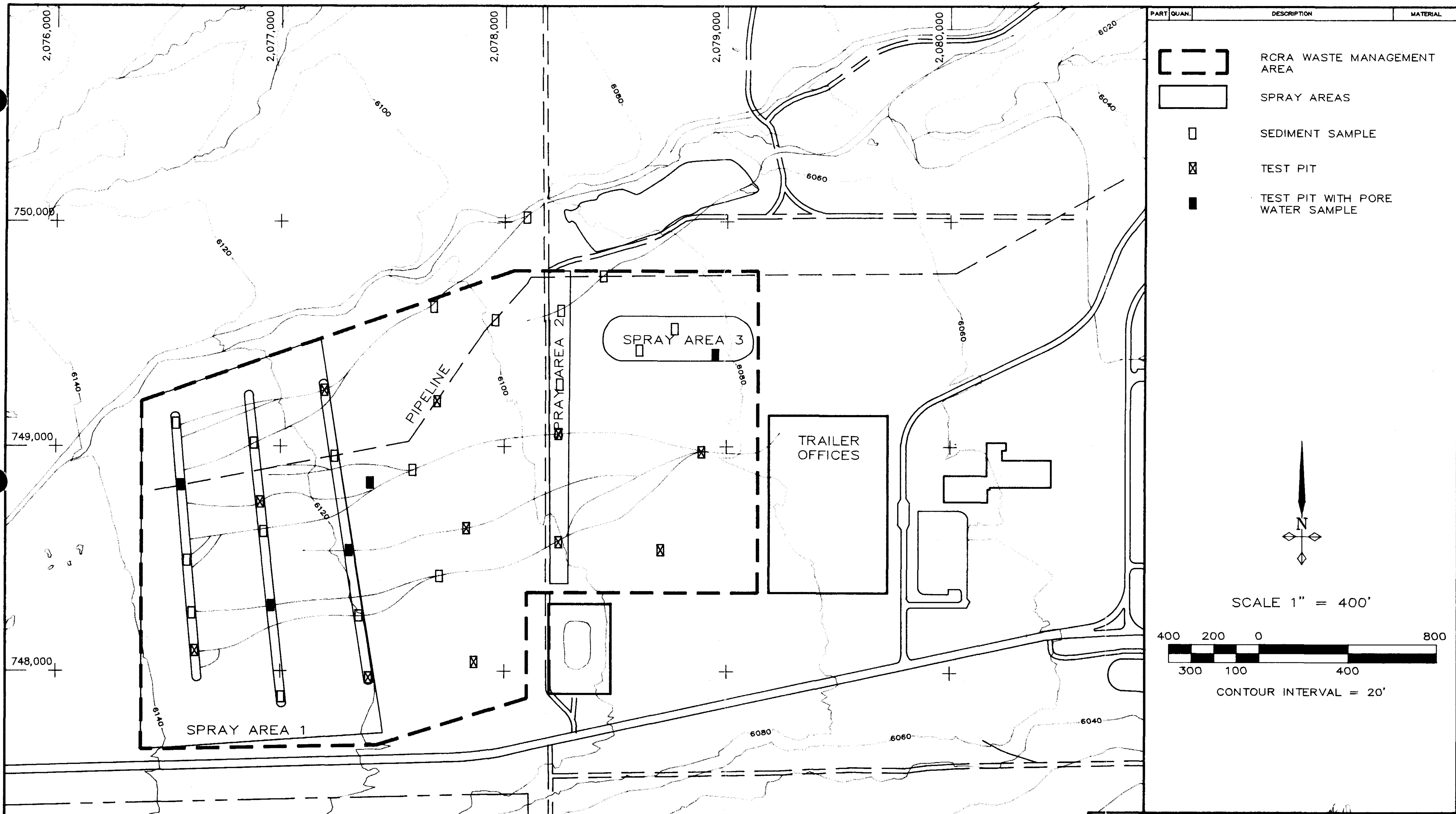
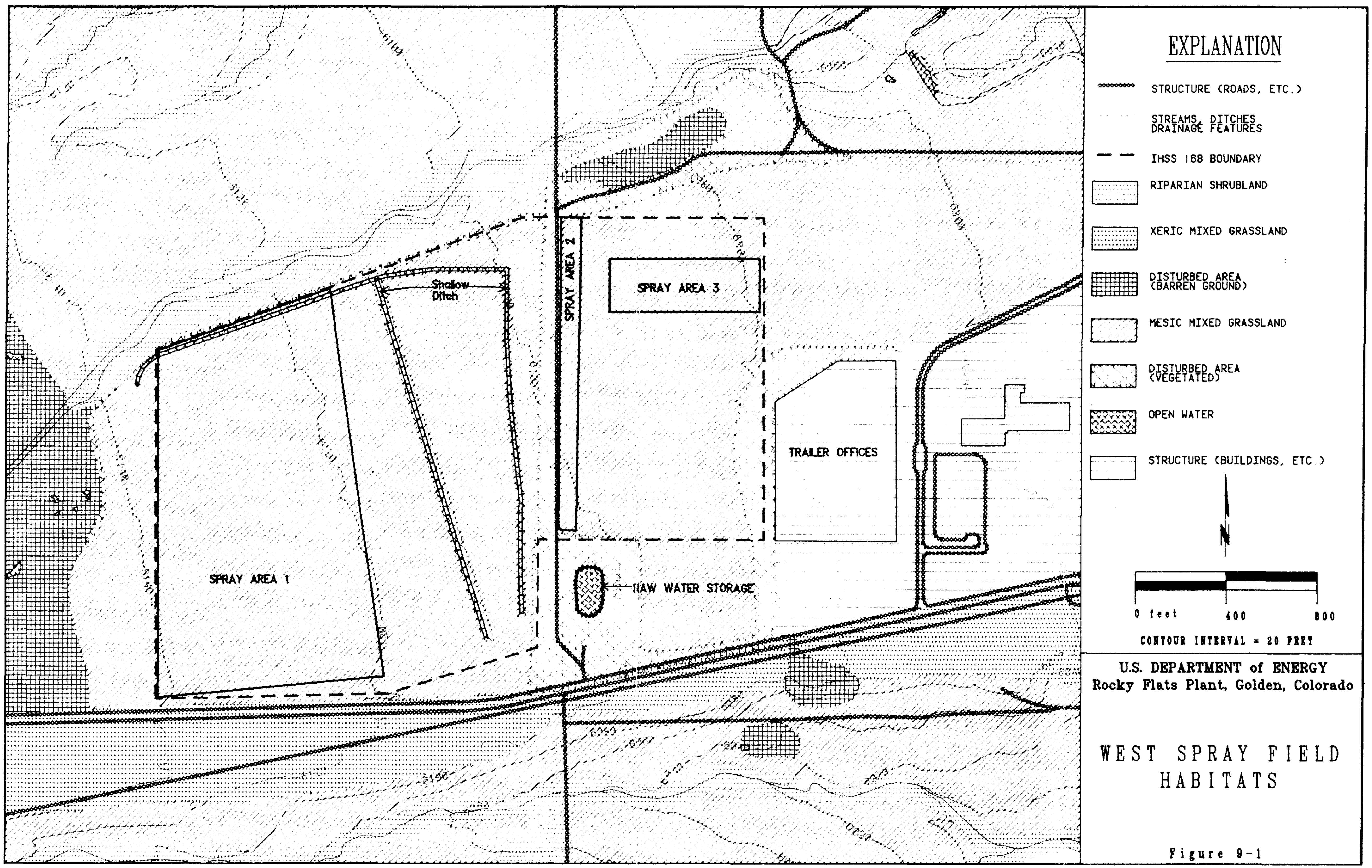


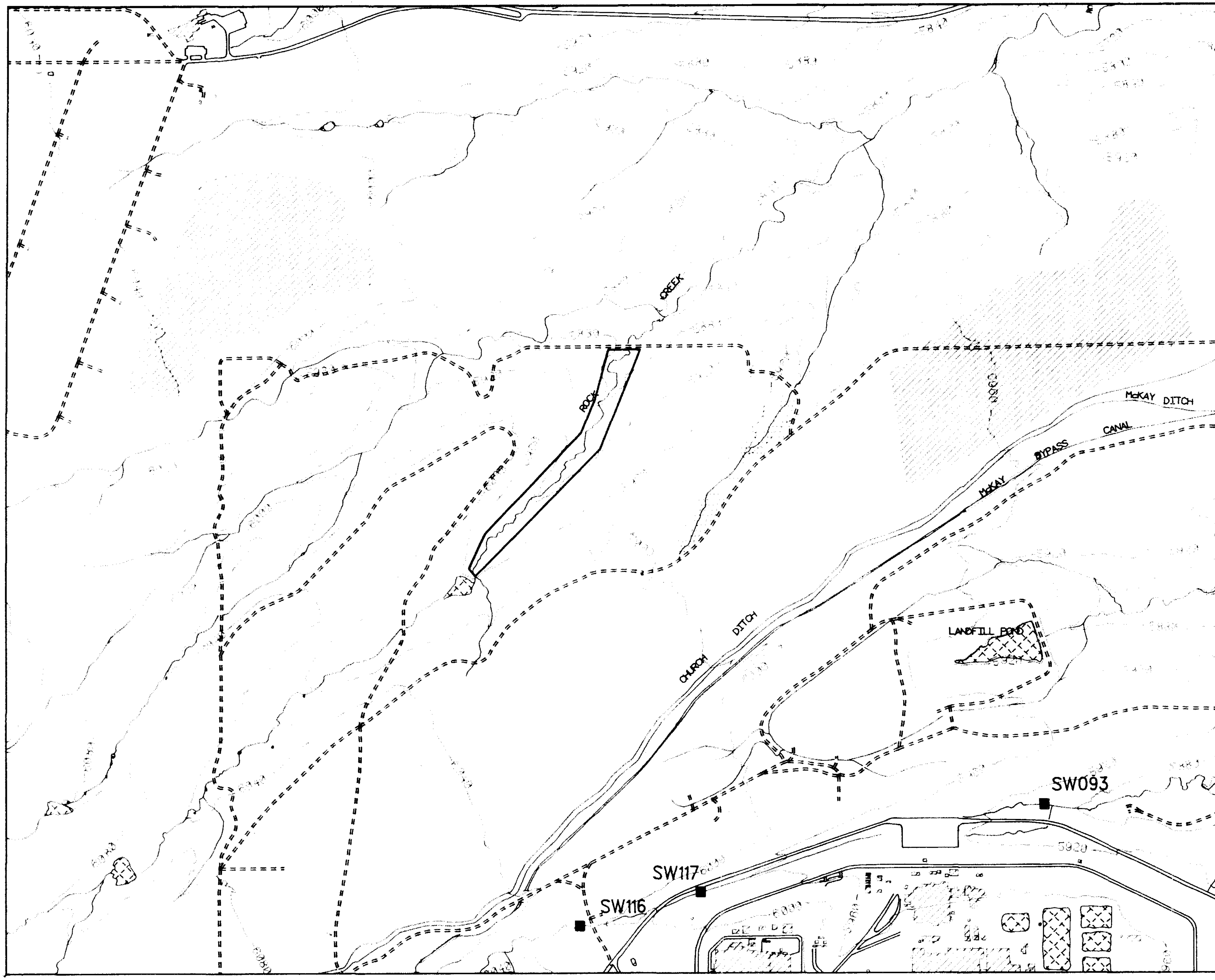
KEYWORDS	A	ORIGINAL ISSUE	12/18/91
1. SPRAY	ISSUE	DESCRIPTION	DATE / RFP / DOE / CLASS / JOB NO.
2. FIELD		DESIGNED CORBETTA	U.S. DEPARTMENT OF ENERGY ROCKY FLATS AREA OFFICE GOLDEN, COLORADO
3. WEST		DRAWN SCHACKLIN	Rocky Flats Plant GOLDEN, COLORADO 80401
BLDG./FACILITY SITE		CHECKED KRAESIG	OPERABLE UNIT 11– WEST SPRAY FIELD
ROOM/AREA WEST		APPROVED	SAMPLE LOCATION
GRID COOR./COL. NO. 748,000N 2,078,000E		SUBMITTED	SIZE B / DRAWING NUMBER FIGURE 7-2 / ISSUE A / SHEET OF
MASTER YES ☐ NO ☒	SCALE: AS NOTED	APPROVED RFP / APPROVED DOE	

"COMPUTER–GENERATED: NO MANUAL CHANGES ALLOWED"



EXPLANATION
STRUCTURE (ROADS, ETC.)
STREAMS, DITCHES DRAINAGE FEATURES
IHSS 168 BOUNDARY
RIPARIAN SHRUBLAND
XERIC MIXED GRASSLAND
DISTURBED AREA (BARREN GROUND)
MESIC MIXED GRASSLAND
DISTURBED AREA (VEGETATED)
OPEN WATER
STRUCTURE (BUILDINGS, ETC.)
0 feet 400 800
CONTOUR INTERVAL = 20 FEET
U.S. DEPARTMENT of ENERGY
Rocky Flats Plant, Golden, Colorado
WEST SPRAY FIELD
HABITATS
SPRAY AREA 1
SPRAY AREA 2
SPRAY AREA 3
Shallow Ditch
RAW WATER STORAGE
TRAILER OFFICES

Figure 9-1



EXPLANATION

- STREAMS, DITCHES DRAINAGE FEATURES
- PAVED ROADS
- DIRT ROADS
- AQUATIC (TISSUE ONLY)
- RIPARIAN SHRUBLAND
- MIXED MESIC GRASSLAND
- SURFACE WATER IMPOUNDMENTS
- BUILDINGS
- AQUATIC SAMPLE LOCATIONS

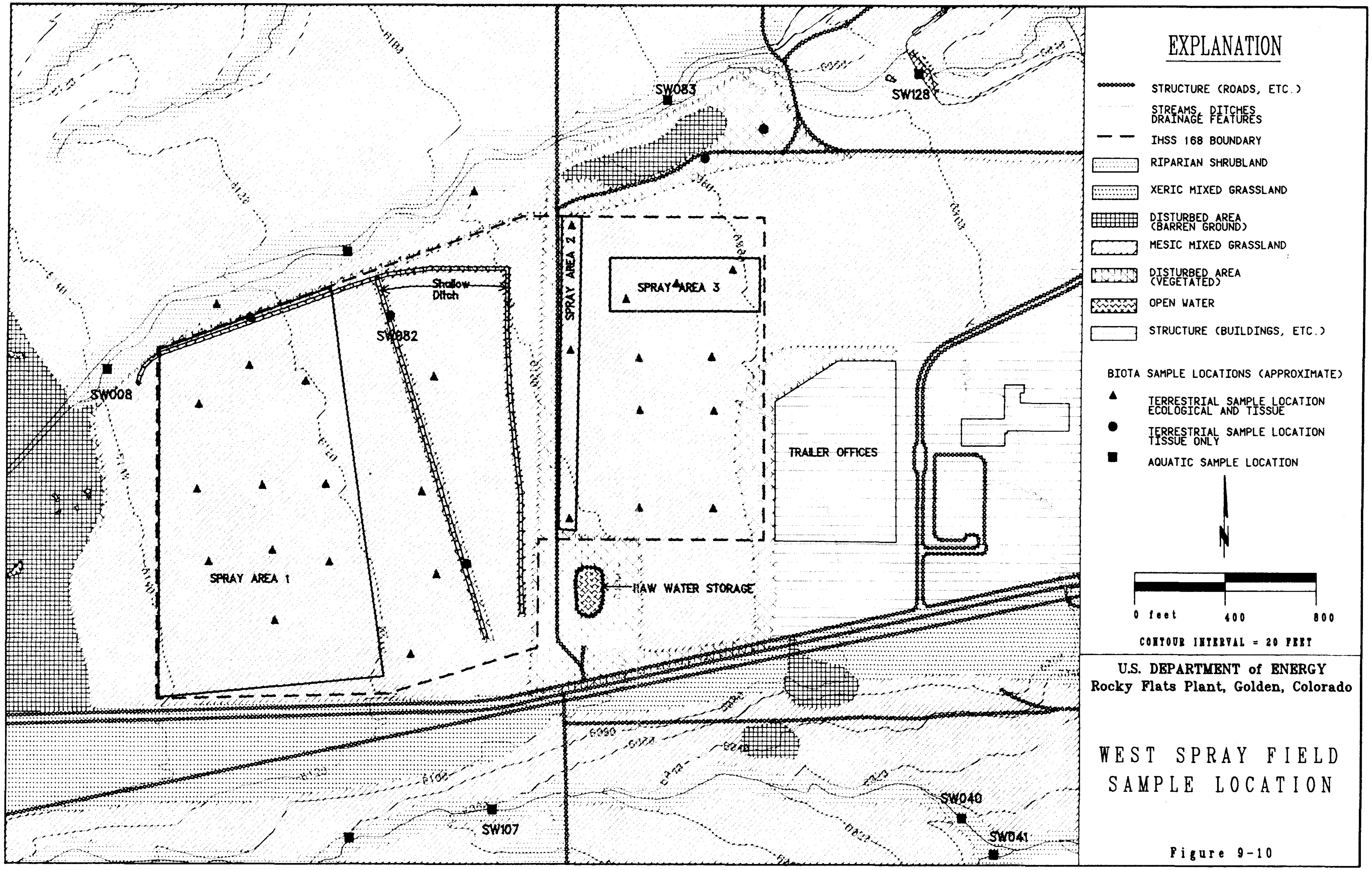
N

0 feet 800 1600

U.S. DEPARTMENT of ENERGY
Rocky Flats Plant, Golden, Colorado

REFERENCE AREAS

Figure 9-7



U.S. DEPARTMENT of ENERGY
Rocky Flats Plant, Golden, Colorado

WEST SPRAY FIELD SAMPLE LOCATION

Figure 9-10